SCIENCE

New Series
Vol. LI, No. 1314

Friday, March 5, 1920

Single Copies, 15 Cts.
Annual Subscription, $6.00

SCIENCE

Friday, March 5, 1919

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to The Editor of Science, Garrison-on-Hudson, N. Y.

SOME ASPECTS OF PHYSICS IN WAR AND PEACE[1]

PART I. SOME APPLICATIONS OF PHYSICS TO WAR PROBLEMS

A year ago in Baltimore we met with peace in prospect. The armistice had been signed. But like a strong runner who had just gotten under way we found it difficult to stop. We continued many of the programs of war. Many of us were still in uniform. Our thoughts were still largely concerned with those problems upon which we had been engaged. But now most of us are back to our normal pursuits, eager as we had been during the war to contribute our energies to securing the welfare of the nation. The tumult and the shouting dies, the captains and the kings depart, still stands the ancient and abiding sacrifice, the labor of unselfish service which we regard as the natural birthright of scientific men.

We are still too near the war to get a clear perspective of the extent to which the various agencies contributed to its successful prosecution. But we can examine it in part and later the results of our examination can be gathered together. It had been my intention to pass in review the many ways in which physics had been applied to the problems of war, but these had been so numerous and so extensive that my time would be given to a mere enumeration of the activities. For the war was one of many elements and many dimensions. Leaving aside the human and, I may add, the inhuman elements, and considering those confined to space, we had warfare in the air, on the surface of the earth, under the earth, on and under the sea. Applications of science were everywhere. Many of the applications of physics have been presented else-

[1] Address of the vice-president and chairman of Section B—Physics—American Association for the Advancement of Science, St. Louis, December, 1919.

where and at length. You have been told the story of aviation, of the physical laboratory on wing; the story of wireless between stations on the surface of the earth, under water and high in the air; the story of signaling through the darkness of night or the brightness of day; the story of sound-ranging, of spotting enemy guns and the explosions of our own projectiles seeking out those guns and of the re-directing of our guns until those of the enemy had been destroyed; the story of submarine detection and of the extremely valuable applications which the study of that problem brought to us—the ability literally to sound the ocean—the ability to guide a ship through fog or past shoals. These and other stories you know. Indeed, many of you contributed to their unfolding. It is my desire here to present briefly some developments in a branch concerning which little has been written, viz., warfare with guns, projectiles, bombs. Later I want to turn from the contemplation of problems of war to view our subject in its relation to peace.

The English playwright, John Drinkwater, represents Abraham Lincoln as saying "the appeal to force is the misdeed of an imperfect world." Unfortunately the world is still imperfect. In the horrible business of killing people in war, guns of all sizes and kinds are the effective weapons. Have you reflected on the enormous extent to which artillery was used in the Great War? According to Sir Charles Parsons, on the British Front alone, in one day, nearly one million rounds of nearly 20,000 tons of projectiles were fired. Extend this along both sides of the Eastern and Western fronts and you may gain some idea of the daily amount of metal fired by guns.

The actual American contribution of artillery to the war was very small but at the time of the Armistice we were making progress. In America we often measure things by money. The total amount of money authorized for artillery, including motor equipment, was $3,188,000,000, and for machine guns was $1,102,600,000. Judged by the money expended for them, guns are of importance. It is essential that we get as effective guns as possible and that we know how to use them. Aircraft, and anti-aircraft warfare, barrage firing, long range guns—all of these call for a very complete and accurate knowledge concerning the motion of a projectile and the energy required to carry it to a certain place and to cause it there to explode at a chosen time. Exterior and interior ballistics are thus matters of great importance.

For two hundred years or more the subject of exterior ballistics has been regarded as belonging to pure mathematics. But into this realm physicists at times intruded. To Newton we ascribe the law that the resistance which a body experiences in passing through the air varies as the square of the velocity. But that great scientist made it clear that that might not be the only law. Euler, one hundred and fifty years ago, proved various mathematical results. Assuming the air resistance to vary as the square of the velocity and that the density of the air did not change with altitude, he showed that the coordinates x, y, and the time can be computed by quadratures. His method of taking the angle of slope of the trajectory as the independent variable has been followed by most of his successors in ballistics.

Even in Euler's method the variation of the density of the air with altitude can be allowed for by using small arcs and by changing the constant of proportionality in the law of air resistance to accord with the new density. His method can in general be followed where the law of air resistance is that given by Mayevski, viz.,

$$R = \frac{A_n V^n}{C}$$

where

$n = 2$	for V between	0 and	790 f.s.
$= 3$		790	970
$= 5$		970	1,230
$= 3$		1,230	1,370
$= 2$		1,370	1,800
$= 1.7$		1,800	2,600
$= 1.55$		2,600	3,600

Siacci, with his elusive pseudo-velocity, has been the chief contributor along this line. His

method as elaborated by Ingalls and Hamilton has been the standard in American works on ballistics.

In Mayevski's law as given in American texts

$$R = \frac{A_n V^n}{C},$$

C is called the ballistic coefficient. Being the reciprocal of a resistance it represents the penetrating power or ability of a projectile to continue in motion. It is assumed to be constant for any definite projectile. But it was found that when the angle of elevation was changed, or even the muzzle velocity, in general C had to be changed to allow for the new range. Attempts have repeatedly been made to find a functional relation between C and these variables. At certain proving grounds in the United States a relation was supposed to have been established but we find that the law adopted does not agree with data which we have secured from Aberdeen. It follows that, though the mathematical computations have been carried through with great rigor and accuracy, actual firings for various elevations have to be made in order, from the ranges observed, to compute the ballistic coefficient for those elevations. In other words, the ballistic coefficient always contains in it a factor which represents the amount by which the theoretical range has to be multiplied in order to obtain the actual range. If range and time be the only quantities required these can be found by actual firings and almost any approximate law of air resistance will satisfy. But it costs money to range-fire guns. For example, this cost for a 12-inch gun is of the order of $12,000 and for a 14-inch naval gun $20,000. These amounts are apt to be exceeded.

It would be a very great saving in time and money if the range and trajectory of a projectile could be determined with a known powder charge without range firing. This can only be done when the complete law of air resistance is known. The modern problems connected with antiaircraft warfare and with accurate barrage firing absolutely require such a law.

Notwithstanding the fact that the law of air resistance for modern projectiles is unknown and that the ballistic coefficient merely represents an approximate relation between the theoretical and actual ranges, great confidence has been placed in so-called experimental determinations of this quantity. For example, in the official manual for the U. S. Rifle the value of the ballistic coefficient of the ordinary service rifle bullet (.30-inch caliber) is given as 0.3894075 "as determined experimentally at the Frankford Arsenal." The experimental skill which can determine to an accuracy indicated by seven places of decimals a quantity as highly capricious as the so-called ballistic coefficient, is of rather questionable value.

Going back to the law of air resistance, it is evident that Mayevski's law is not satisfactory either to mathematicians or to physicists. There are abrupt changes when the index n is changed. The mathematician can not differentiate at these corners, the physicist can not see the necessity for their existence. The law as laid down by the Gavre Commission which is ordinarily written in the form $R = cv^2B(v)$, where $B(v)$ is a function of v, is satisfactory in that it has no discontinuities. But though it is satisfactory in this respect it may still be incomplete.

The Gavre law or any other smooth law lends itself to numerical integration by the method of Gauss, who developed it one hundred years ago. He used this method in the problem of special perturbations in celestial mechanics. It has since been presented in some text-books in theoretical astronomy. An early application to physics curiously enough was made by an astronomer, John Couch Adams, in the integration of an equation occurring in the theory of capillarity. But though Adams was thoroughly acquainted with this method he apparently did not feel that it was as satisfactory for computing a trajectory as that of Euler. For in an article on "Certain Approximate Solutions for Calculating the Trajectory of a Shot" (Collected Works), he refers the motion to the angle that the tangent to the trajectory makes with

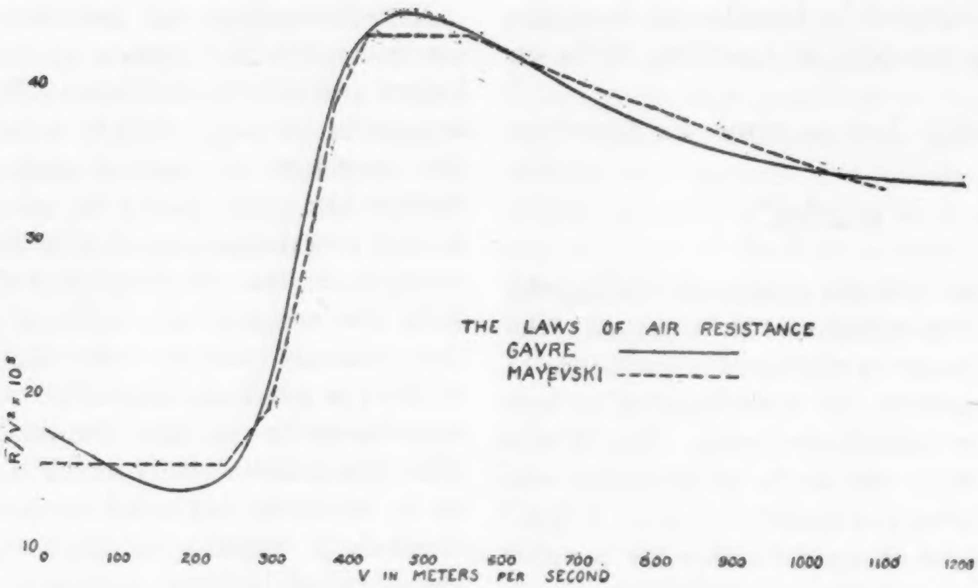

FIG. 1.

the horizontal and uses as a resistance law $R = A_n V^n$, the constants being taken from Bashforth's experimental results.

The method of Gauss, *i. e.*, of using rectangular coordinates, has been used by physicists, to first order differences at any rate, for various computations. In the case of a projectile, if the retardation follows the square law $R = kv^2$, the equations of motion take the well-known form

$$\frac{\partial^2 x}{\partial t^2} = -k\frac{\partial s}{\partial t}\cdot\frac{\partial x}{\partial t},$$

$$\frac{\partial^2 y}{\partial t^2} = -g - k\frac{\partial s}{\partial t}\cdot\frac{\partial y}{\partial t},$$

or

$$\ddot{x} = -kv\dot{x},$$

$$\ddot{y} = -g - kv\dot{y}.$$

If we take as the law of retardation

$$R = cv^2B(vy) = vF(v\cdot y) \quad \text{where} \quad F = \frac{G(v)H(y)}{C}$$

the equations take the form

$$\ddot{x} = -\dot{x}F(v\cdot y),$$

$$\ddot{y} = -g - \dot{y}F(v, y).$$

The change in the retardation due to change in density of the air with height y can be taken account of in the function $H(y)$. As a result of many meteorological observations $H(y)$ may be written

$$H(y) = 10^{-.000045y},$$

y being measured in meters.

In the notation introduced by Professor Moulton $G(v), = vB(v)$, is computed directly from the French tables giving $B(v)$ as a function of v. The form of the function $B(v)$ plotted against v is shown in Fig. 1, and will be called the B curve.

Now if C the ballistic coefficient or penetration coefficient, and the velocity and altitude are known at any time, then $\ddot{x}$ and $\ddot{y}$ are known. If these x and y retardations are constant or nearly so, then the values of the x and y velocities at any later time are known if the time intervals be short. But the retardation depends on the velocity, hence its value for any interval will in general lie between the retardations computed for the velocities at the beginning and end of an interval. One is soon able to approximate to the average—consequently the values of the x and y velocities at the end of the first, and beginning of the second, interval are known. Integration can be performed to find the new x and y and the process can be repeated for the next interval.

After x and y and their first and second derivatives are tabulated for the first four or five short intervals (of $\frac{1}{4}$ or $\frac{1}{2}$ second), first and second differences are tabulated and the computation can proceed in longer time intervals, usually one or two seconds. The formulas for extrapolation are made use of for extending the computation, and the results

are checked. Hence a trajectory can be computed taking account of variations of air density with height, and satisfying at all points the assumed law of retardation.

Since the retardation depends on the relative velocity of air and projectile, winds can be allowed for by considering the motion relative to the air at every point. This involves the principal of moving axes. It implies however, that the projectile is a sphere or that the retardation is independent of the angle which the projectile presents to the air, or else that the projectile always turns nose on to meet the air. We know, however, definitely that an air stream of a few miles per hour at right angles to the axis of a projectile may have several times as great a force as the same stream would exert along the axis, and that a spinning projectile can not turn quickly to meet every wind that blows, even though the wind may have but small influence upon the angle at which the air meets the projectile.

It was this method of short arc computation which Professor Moulton applied to the problem of exterior ballistics when he was made head of that branch in the Ordnance Department. For his courage in setting aside the long-established, revered but rather empirical method in use in the War Department, and in introducing a logical, simple method of computing trajectories, and for his energy in initiating and pushing through certain experimental projects, he deserves great commendation. Valuable contributions to the method were made by his associates, notably Bennett, Milne, Ritt. Professor Bennett devised a method which has a number of points of merit. It is the one now used at the Aberdeen Proving Ground. Professor Bliss gave an inclusive method of computing variations in range, altitude and time due to changes in air density, winds, muzzle velocity. Dr. Gronwall greatly simplified and extended the work by Bliss, and made other important contributions. In short, leaving out of account the question as to the correctness of the law of air resistance, the variation of that resistance with the angle of attack of air and projectile, leaving out the motion of precession and nutation which are dependent upon the transverse and longitudinal moments of inertia of the projectile and its rate of spin—leaving out these factors the mathematical basis for finding the trajectory of a projectile is secure.

But the system of forces under which a projectile moves is not the simple one implied by the equations just given. For a projectile is a body spinning rapidly about an axis probably nearly identical with its geometrical axis. It emerges from the gun either with a small yaw, or with a rate of change of yaw, or both. (By yaw is meant the angle between the axis and the direction of motion of the center of gravity.) As in the case of a top, processional motion results. If the motion is stable, precession accompanied by nutation continues. If unstable, the axis is driven farther from its original direction until the projectile is "side on" to the air, or "base on" to the air. In short, the projectile tumbles. Loss of range and great dispersion are the results.

The condition for stability may be taken the same as that for a top spinning about an axis nearly vertical, viz.,

$$S = \frac{A^2N^2}{4B\mu} > 1,$$

where

A = moment of inertia about the axis of spin

B = moment of inertia about an axis at right angles

N = frequency of spin in radians per sec.

$\mu \sin \theta$ = moment of force about an axis through the C.G. at right angles to the axis of spin, where θ is the yaw *i. e.*, the angle between the axis of the shell and the direction of motion of the center of gravity.

The rate of orientation of the yaw or the precessional velocity is given by

$$\dot{\varphi} = AN \div B(1 + \cos\theta).$$

The relation given for stability, viz., that

$$\frac{A^2N^2}{4B\mu} > 1,$$

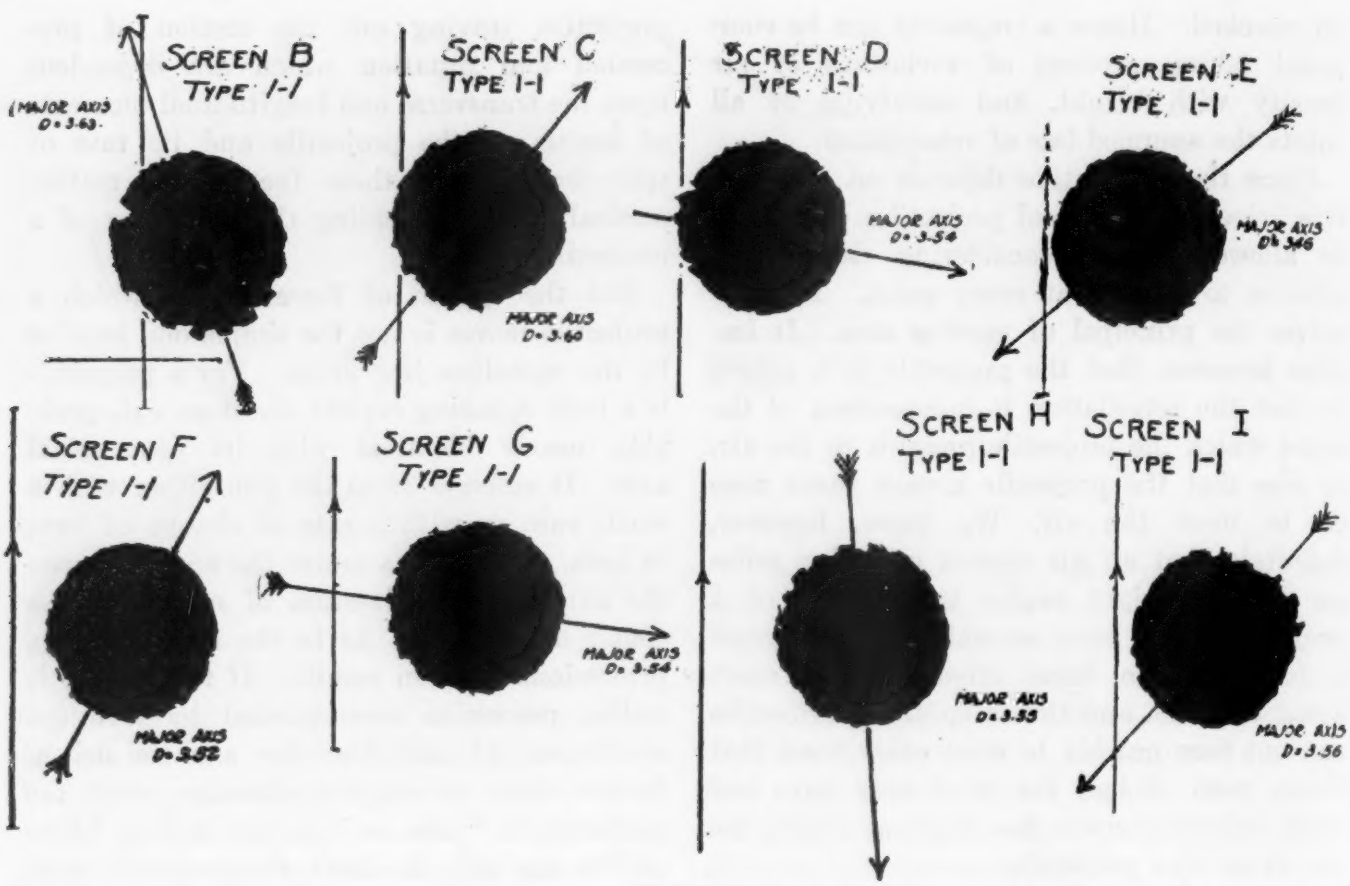

Fig. 2.

is based on the assumption that the torque due to the air is proportional to sin θ. Our air stream experiments throw doubt upon this assumption but the English experimenters, who have made the most complete studies of the rotational motions of projectiles that we know of, seem to confirm it.

These motions of precession and nutation of a projectile can be studied by firing through a number of cardboard screens spaced at equal distances along the line of fire. As has been said, the English have been the foremost investigators in the work. At Aberdeen, under the immediate supervision of Mr. R. H. Kent, a very extended study, following in general the English method, is being made of the stability of projectiles. Cardboard screens are placed at distances of 20 feet from one another for some distance from the gun, then at 100 feet, then at 20 feet again towards the end of the path. A careful study was made of cardboard so as to obtain a kind which would give a clean cut hole. The lantern slide (Fig. 2) shows the variation of the major axis of the hole for eight consecutive 20-foot screens.

It will be seen from Fig. 2 that the major axis of the hole in screens B and C made by the 3.3 inch projectile is about 3.6 inches, and between those screens the angle of the major axis has turned through about 60°. At screens D, E, F, the major axis is about 3.5 inches and it turns rapidly. Here the yaw is a minimum and the rapid motion of the axis is in accord with the theory governing nutation.

If the projectile were moving in a vacuum or if the air forces did not influence the motion, the precessional velocity ϕ' (considered uniform) would be given by

$$\phi' = \frac{AN}{B(1+\cos\theta)} = \frac{AN}{2B}.$$

For the projectile in question $N = 220$ turns per second.

$$\frac{A}{B} = 1/6.$$

Hence $\phi' = 220/12 = 18.3$ turns per second.

Since the muzzle velocity is 2,300 feet per second and the screens are 20 feet apart, this frequency is nearly equal to that of the precessional motion at maximum yaw.

The discussion just given shows what a difficult matter it is to measure the retardation of a projectile by firing through screens. For the retardation must be not only a function of the velocity but also of the yaw. As the latter is periodic there will be a periodic term superimposed on the general term. While the ordinary law may lead one to suppose that the retardation would continually decrease as the velocity dies down it may actually go through the cycle of decrease, increase. For the same reason we may find that the retardation for a shell fired from a gun rifled 1 in 25 may differ from that for the same shell and velocity when the rifling is 1 in 50.

It has been indicated that previous to the introduction of the method of short arc computation by Moulton there had been little change in the field of exterior ballistics in America for several years. In experimental work there had been rather slow progress. That the progress was slow was not so much the fault of the Army as it was due to the non-military policy of the country. When no importance is attached to military affairs by the people we can not expect our army officers to place their service in a position of world prominence.

Recently my attention was called to a letter which may throw light upon one reason for the fact that experimental work was very limited. This letter was written in 1907 from the Ordnance Board to the Chief of Ordnance, requesting that $40 be allowed for experiments in determining the effect on range produced by changing the points or ogives of 50 three-inch projectiles. The experiments were authorized and the money allowed. Trials with only 15 of the 50 projectiles showed that the range was increased from 5,042 to 5,728 yards. It was reported that the coefficient (βc) had been changed from .97272 to .68705. (Note again the extraordinary accuracy in *measuring* this quantity!) The colonel in charge of the experiment deemed further work unnecessary, for he writes (9th indorsement):

> Having established the probable form of the field projectile the board recommends that the remaining 35 experimental shells be made to conform to this design.

However, the Office of the Chief of Ordnance considered that the last word had not yet been said concerning the best form of projectile, and ordered certain other variations to be made in 10 of the remaining 35 projectiles. To provide for this further test it was stated that "a sum of $25 . . . has this day been set aside on the books of this office as a special allotment." (And this was only seven years before the World War started.)

It may be further stated that to this letter authorizing $65 for experimental tests of shells there were 15 indorsements. Those of you who have been in the service will appreciate what this must have meant in the time of stenographers, messengers, filing clerks, and high-salaried officers.

That perfection in the form of projectiles had not been secured was made evident by a series of experiments, rather crude as judged by physical standards, begun at Sandy Hook in 1917, and continued at Aberdeen in 1918. It had been noticed that there was very large dispersion of the shells of the 6-inch gun and the 8-inch howitzer. Various book theories were advanced to account for these dispersions, but finally upon an examination of some recovered shells and as a result of the information obtained by firing through cardboard screens, the true explanation suggested itself. The rotating band on these shells had a raised portion, called a lip, at the rear of the band (Fig. 3). The purpose which this lip was supposed to serve was to act as a choking ring to prevent the escape of the powder blast past the projectile and to seat the projectile at a definite place in the gun. It was seen in the case of the recovered projectiles, and it was evident by the hole formed in the cardboard screen through which the projectile had passed, that these lips were

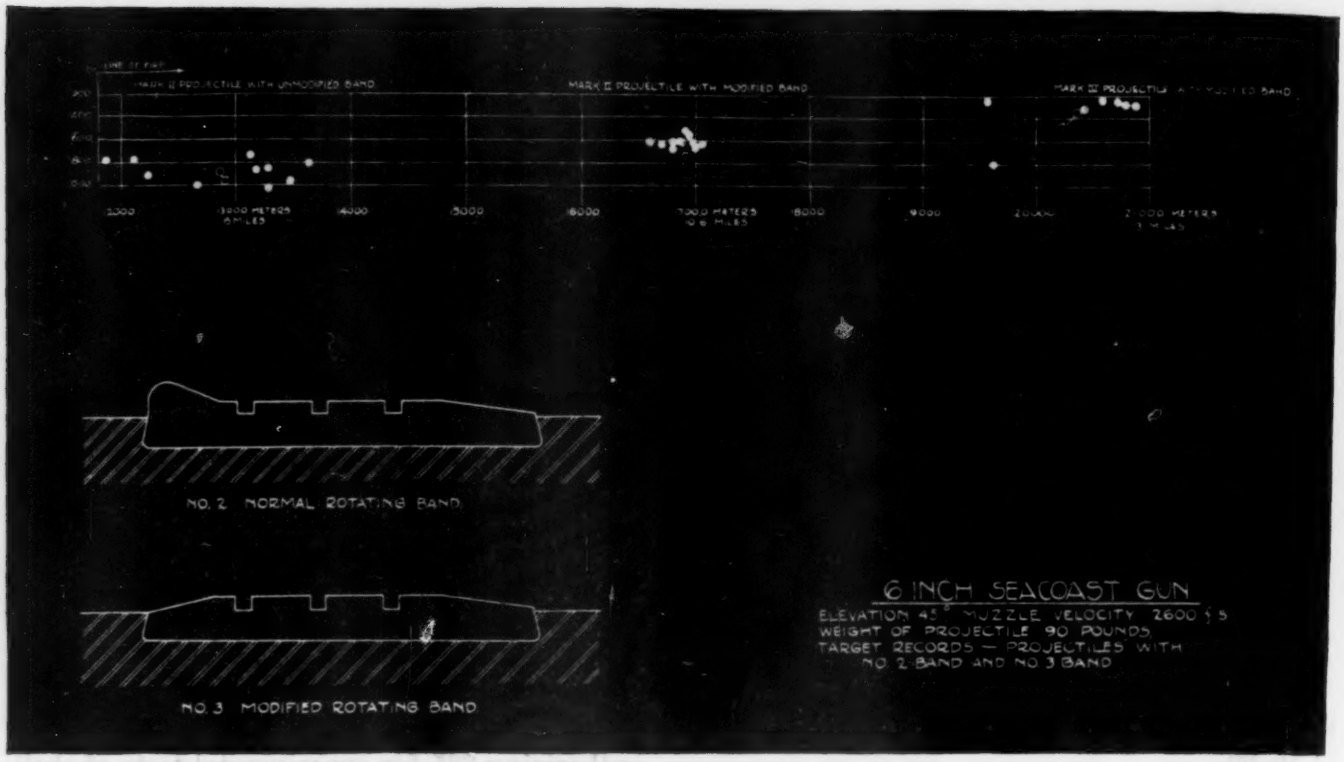

FIG. 3.

partly torn off in the passage of the projectile through the gun. Experiments were then begun in modifying the band. These modifications consisted of machining off the lip as in Fig. 3. The results were very gratifying. The 8-inch howitzer projectile had its range increased by 700 meters and its dispersion decreased in the ratio of 4 to 1, while the 6-inch shell at a muzzle velocity of 2,600 feet per second and elevation of 45° had its range increased from about 12,000 to about 16,000 yards, and its dispersion was divided by four.

A number of experiments of this kind were carried on at Aberdeen, chiefly by Major

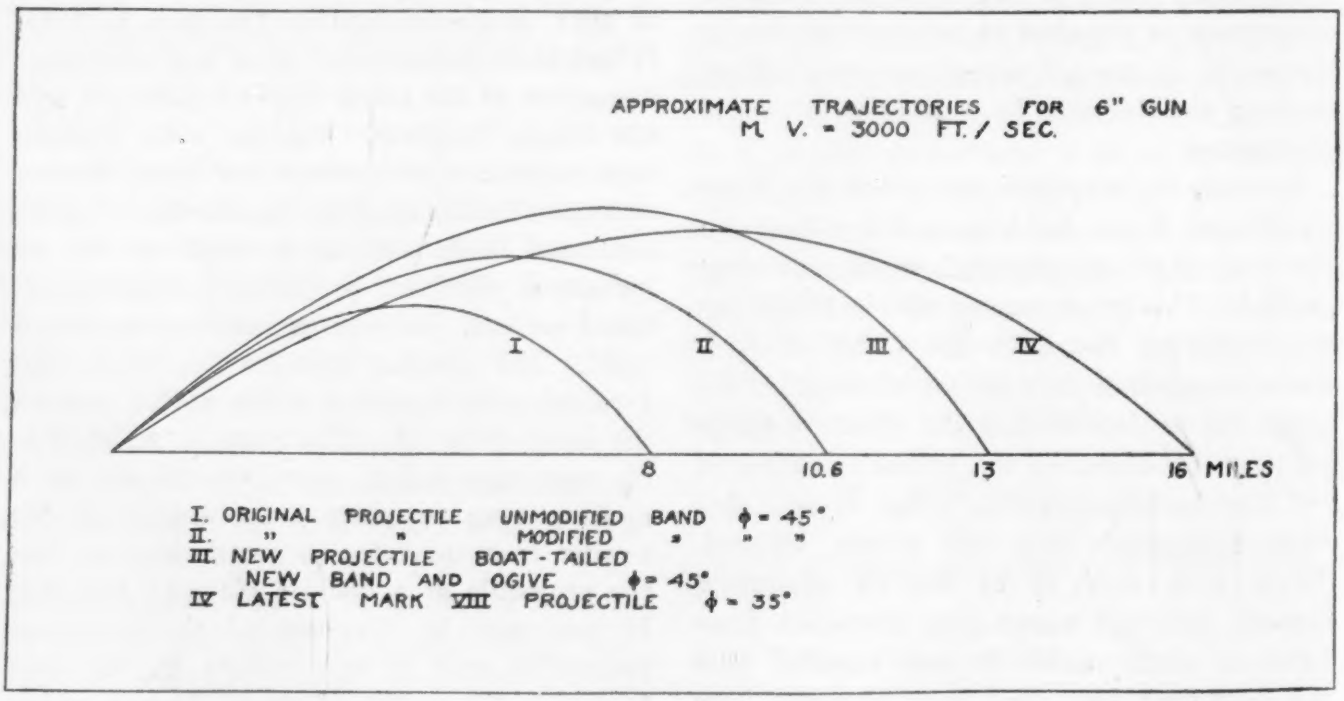

FIG. 4.

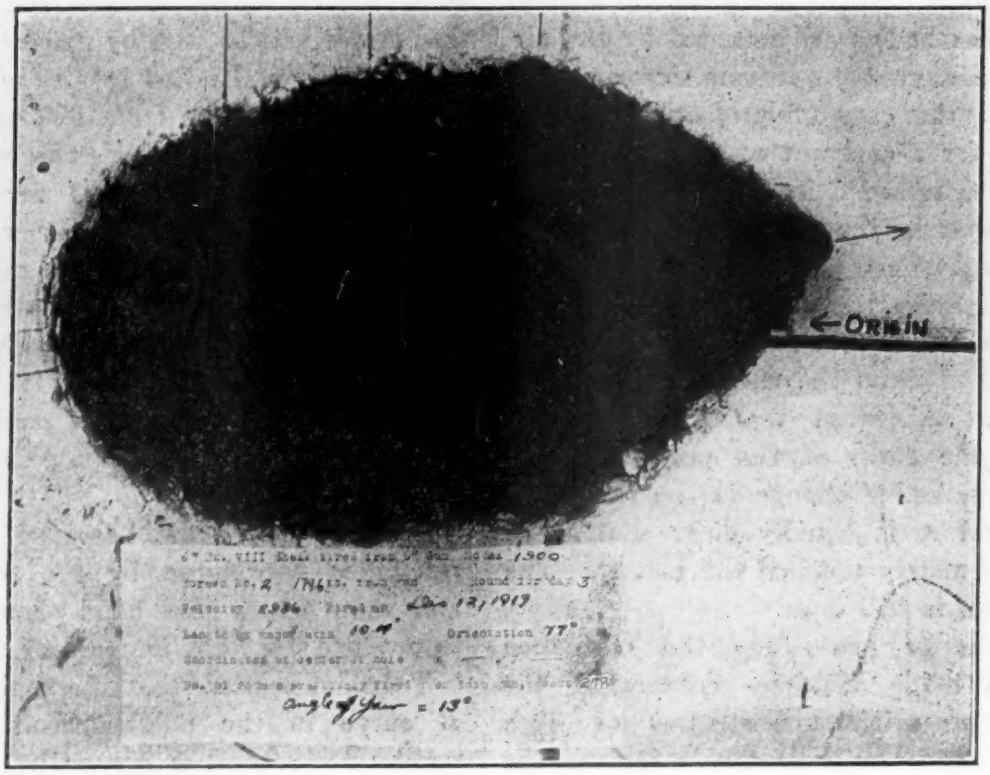

FIG. 5.

Veblen and Lieutenant Alger. In France, similar work was done by Captain R. H. Kent. It is seen that these experiments added greatly to the effectiveness and therefore to the value of the guns in question. The work belongs to physics, notwithstanding the fact that one of these civilian officers was and is a professor of mathematics of the purest quality. That he was able to bring himself temporarily to neglect the fundamental concepts of geometry, in which realm he is one of our foremost thinkers, to enter into the problems of the war with an eagerness for close observation of actualities and a readiness to try out new methods, is very greatly to his credit. He is evidently a physicist by intuition and a mathematician by profession.

It is to be noted (Fig. 4) that between the summers of 1918 and 1919 the range of the 6-inch seacoast gun had been increased from about 14,000 yards to 28,000 yards[2] for a muzzle velocity of 3,000 feet per second, by variations in the form of the projectile suggested by crude experiments. In the case of the last projectile (Mark VIII.) there was rather large dispersion. Had the cardboard test been made it could have been foreseen that there would be this dispersion, for the projectile is evidently not sufficiently stable. In Fig. 5 it is seen that one projectile (6-inch Mark VIII.) has acquired a large yaw not far from the gun. This accounts for the fact that the dispersion for this projectile was large, of the order of 3,000 yards in 28,000.

It may be contended that some of the experiments and tests here recorded are too crude to be classed as belonging to the domain of physics. But let me remind you that Galileo, who may be regarded as the father of our science, climbed the tower of Pisa and let fall two weights, one large and one small, to show that they fell in the same way. We

[2] The range of 14,000 yards for the 6-inch gun is computed for a muzzle velocity of 3,000 feet per second at 45° elevation, basing the computation on the range obtained with a muzzle velocity of 2600 f.s. It ought to be pointed out that the Army had a 6-inch shell which for a muzzle velocity of 2,600 feet per second had a range of 15,000 yards at 15° elevation, but this was a heavy projectile—108 lbs.—while that of the projectile experimented upon was 90 lbs.

have made some progress since Galileo's time. We know that bodies are retarded by the air but we have assumed, on some experimental evidence, in the case of projectiles at any rate except for a constant of proportionality, that they are retarded in the same way. It is evident that in the matter of the laws of air resistance we are not far from the condition that the scientists of Galileo's time were in regard to gravitation.

It is evident from the results of these experiments at Aberdeen that a very slight change in the form of the projectile may make a considerable change in the range obtained. And it is equally clear that those experiments merely touched the matter. The entire subject is still open.

A number of years ago the Ordnance Department made inquiries concerning the possibility of using air streams of high velocity in tests on projectiles. During the war the project was submitted to the National Research Council. It was found that air streams one foot in diameter, with speed of 1,500 feet per second, requiring for their production 5,000 kw., could be furnished by the General Electric Company at their plant at Lynn, Massachusetts. There, with the most loyal support of the Bureau of Standards, and with the effective collaboration of Dr. L. J. Briggs of the bureau the Ordnance Department has conducted experiments[3] which have for their object the determination of the forces of such air streams on projectiles of various forms. Velocities of the air have, so far, varied from 600 up to 1,200 feet per second and temperatures from 0° to 130° C. In these air streams, which are vertical, projectiles of various shapes can be held nose down, and the forces on them and pressures at various points on their surfaces, can be measured. A number of important results have been secured. First, for head-on resistance there is no *one* curve similar to the French *B* curve which gives the law of air resistance for all projectiles. For example, in that law it will be seen by inspection (Fig. 1) that F/v^2 is multiplied by the factor 3 when the velocity changes from 200 to 380 meters per second. In our curves the corresponding factor varies from 1.3 to 4 for the various forms of projectiles. In other words the force exerted on one projectile may be less at one velocity and more at another than the force for the corresponding velocity in the case of another projectile. It follows that there is no "best form" of projectile unless we specify the approximate velocity with which we are dealing.

Second, the results obtained indicate the resistance introduced by the rotating band and show where this band should be placed to produce the least increase of resistance.

Third, it appears that the rapid rise of the *B* curve in the neighborhood of $V = 340$ meters per second is not entirely determined by the velocity of the compressional wave, *i. e.*, by the velocity of sound in the air. In some cases the force of air streams at 130° C. are identical with those at 30° C. (It is understood that the density of the air is standardized, *i. e.*, that the forces plotted are those which an air stream of equal speed and of density 0.001206 gms./cm.^{3} would have exerted.) In other cases, however, the results indicate that the velocity of the compressional wave is one of the factors determining the resistance. The temperature relation seems to be a complicated one and our results are not at all complete on this point.

Fourth, though we have not made quantitative measurements of the variation of force with the angle of attack of air and projectile, we have had some experimental evidence of the large forces which are called into play when this angle changes from "nose on" to oblique. In one case, the force of the air on a fifty pound 4-inch projectile was of the order of 44 pounds, so that there was still about six pounds of down force. When the projectile was being removed from the air stream it was accidently tipped slightly. The air stream forced it farther from the vertical, bent off the steel rod holding it to the balance

[3] Without a knowledge on his part of other inquiries, negotiations for these experiments were carried on and pushed to a conclusion by Major Moulton.

arm and blew the projectile up several feet over a railing into the yard. In another case, when the up force due to the air on a two-inch projectile was only about one third of the weight, *i. e.,* about 1.5 pounds, an oblique action at a slight angle drove the projectile farther from the vertical, finally turned its nose up, bending the steel spindle in the process. It is evident that the oblique forces of air streams on projectiles may be many times the "nose-on" force for corresponding velocities. It is clear then that unless a projectile turns "nose-on" to a wind the method now in use for finding wind corrections are greatly in error.

Enough has been said to show that the fundamental problem of the projectile is not one of mathematics. There are various mathematical methods of handling the problem. The English have a method highly analytical and complete. The French have a method rather tedious for computation but they excel in the graphic representation of results. The Italians still cling to the Siacci method. There are at least three methods in use in America, each one claiming points of merit. The problem is one of experimental science. We must first determine the complete law of air resistance for every probable form of projectile, then we must determine the variation of force as the axis of the projectile changes in direction; the torque about the center of gravity; the precessional and nutational motions under these forces, and the consequent effective lift and drag, as these terms are used in aerodynamics. Mathematicians may then find it necessary, using these known facts, to formulate the differential equations of a twisted trajectory and to evolve methods of integration. But it is quite probable that simple physical methods of integration may be devised.

It is evident even from a superficial study of the matter that a gun is an inefficient engine. An appreciable part of the energy of the powder takes the form of heat and kinetic energy of the gas developed. Of the initial energy of the projectile a large part is used in overcoming the resistance of the air. Perhaps in the warfare of the future we shall not need guns, on land at any rate. Rather we may hoist a carload of projectiles on a dirigible, carry them over the enemy's cities or lines and drop them on carefully selected spots. But if we are to drop projectiles or bombs accurately we must know the laws governing the motion of such bodies.

During the war, Drs. A. W. Duff and L. P. Seig carried on a series of experiments at Langley Field, in which the object was to find by photography the path of a bomb dropped from an airplane. By placing an intense light in a bomb they were able to photograph its path, to measure its velocity at any point, to obtain the speed of the airplane, and the wind velocity. These important results were contributed to the Americal Physical Society at the April meeting.

At Aberdeen, Dr. F. C. Brown, then captain later major in the Ordnance Department, while flying over a shallow body of still water observed the image of the airplane in the water. To a casual observer this would have excited no special interest. But, being a physicist, knowing the meaning of a level surface and a line of force, Dr. Brown saw that he had with him a visible vertical line. However the airplane tossed and pitched the vertical direction could be identified. He made use of this fact in a very skillful way. Attaching to the airplane a motion picture camera he was able to photograph a bomb released from the plane at a height of about 3,000 feet during the whole course of the projectile to the earth. Time can be obtained either from the rate of motion of the camera or from the photograph of a watch placed so that its image also falls on the film. The distance that the bomb has fallen and its orientation in space can be determined from the dimensions of its image. Its angle of lag or its distance behind the vertical line from the plane can be found by measuring the distance between the image of the bomb and that of the airplane. Hence not only the complete trajectory can be found but also the relation of the trajectory at any point with the variation in direction of the axis of the bomb.

It is assumed here that the motion of the airplane has been kept constant. The motion picture film which I shall show, which was kindly loaned to us by the Aircraft Armament Section of the Ordnance Department, will bring out clearly the tossing, pitching motion of the bomb in its course to the earth.

INTERIOR BALLISTICS

In interior ballistics, there are a number of unsolved problems. The first is concerned with the pressure produced in a gun by the exploding charge and its time rate of change.

The ordinary method which has been in use has been to measure the so-called maximum pressure by the shortening produced in a copper cylinder. But experiments have shown that the amount which a cylinder of copper is compressed by an applied pressure depends on the amount of the pressure, the time of application, the previous history as regards tempering, annealing, compression, etc. It is known for example that an application of a pressure of say 36,000 pounds per square inch will give an extra shortening to a cylinder previously compressed to 40,000 pounds per square inch. But the ordinary procedure has been to place in the gun a copper cylinder which had been precompressed to an amount nearly that to be expected. Obviously such a cylinder may indicate a pressure in the gun in excess of 40,000 pounds when in reality it was less. Moreover, the copper cylinder need not indicate the maximum. Rather it indicates a summation of the total effect of the gases upon it. A smaller pressure applied for some time may produce a shortening equal to that due to a larger pressure for a shorter time. Notwithstanding this uncertainty in the behavior of a copper cylinder, that is the kind of gage which has been used to standardize all the powder used in guns. It is clear that we may doubt whether these powders have been standardized at all. What is wanted evidently is a gage which will register the pressure accurately at a certain instant and therefore which will give the complete variation of the pressure with time.

Several gages have been devised which have points of excellence as well as defects. In the Petavel gage the compression of a steel spring was registered on a revolving drum by a light pointer. But the mechanical processes were not well worked out. Colonel Somers improved on Petavel's design in the mechanical details but neglected the optical. For small arms, both mechanical and optical details have been worked out by Professor A. G. Webster. In the gage the spring is a single bar of steel about 5 mm. square and 20 mm. long, which is bent by a plunger fitting into a cylindrical opening through the wall of the gun. Its moving parts have small mass and high elasticity, and it seems capable of giving an accurate record of the changes in pressure even when the whole time is of the order of a few thousandths of a second. But its use appears to be limited to the cases of guns which can be rigidly clamped during the explosion.

In the Bureau of Standards, Drs. Curtis and Duncan have been perfecting a gage which has been used in the large naval guns. Here a steel cylinder compresses a steel spring. During the compression a metal point makes electrical contact with conductors equally spaced. Consequently electrical signals can be indicated by an oscillograph for these equal steps. The time pressure curve is then given if the spring can be properly calibrated. There is however some doubt on this point and there is also uncertainty in electrical contacts and in the friction of the system.

What is needed is a method of calibrating accurately any gage by means of a known rapidly changing high pressure. Such a method has been worked out by the technical staff of the Ordnance Department, but the mechanical and experimental work still has to be done.

I have given you here some applications of the older physics to old and new problems of war. The list even in this limited field might be easily increased. By means of the photography of sound waves from a projectile we may determine many facts concerning its motion, the frequency of its precessional and

nutational motions, the nature of its stability or instability. By means of motion pictures taken from an airplane we may determine facts of importance concerning the motion of a rapidly rotating projectile dropped from the plane. The recoil, jump and other motions of guns may be studied by photographic methods. By similar methods the times and positions of high angle shell bursts may be obtained from observational balloons. Gyro stabilizers, microphones, string galvanometers, oscillographs, piezo-electric apparatus, vacuum amplifying tubes, Kenetrons, old and new devices in physics—they all may be used to reduce the problems which I have been discussing to those of an exact science.

GORDON F. HULL

DARTMOUTH COLLEGE

BOARD OF SURVEYS AND MAPS OF THE FEDERAL GOVERNMENT

ON December 30, 1919, the President of the United States by executive order created a Board of Surveys and Maps to be composed of one representative of each of the following organizations of the government:

1. Corps of Engineers, U. S. Army.
2. U. S. Coast and Geodetic Survey, Department of Commerce.
3. U. S. Geological Survey, Department of Interior.
4. General Land Office, Department of Interior.
5. Topography Branch, Post Office Department.
6. Bureau of Soils, Department of Agriculture.
7. U. S. Reclamation Service, Department of Interior.
8. Bureau of Public Roads, Department of Agriculture.
9. Bureau of Indian Affairs, Department of Interior.
10. Mississippi River Commission, War Department.
11. U. S. Lake Survey, War Department.
12. International (Canadian) Boundary Commission, Department of State.
13. Forest Service, Department of Agriculture.
14. U. S. Hydrographic Office, Navy Department.

The individual members of the board were appointed by the chiefs of the several organizations named. The board is directed, by the executive order, to make recommendations to the several departments of the government or to the President for the purpose of coordinating the map-making and surveying activities of the government and to settle all questions at issue between executive departments relating to surveys and maps, in so far as their decisions do not conflict with existing law. The board is also directed to establish a central information office in the U. S. Geological Survey for the purpose of collecting, classifying and furnishing to the public information concerning all mapping and surveying data available in the several government departments and from other sources. The executive order further directs that the board shall hold meetings at stated intervals to which shall be invited representatives of the map-using public for the purpose of conference and advice.

All government departments, according to the executive order, will make full use of the board as an advisory body and will furnish all available information and data called for by the board.

The order of the President rescinds the advisory powers granted to the U. S. Geographic Board by the executive order of August 10, 1906, and transfers those powers to the Board of Surveys and Maps. The executive order of August 10, 1906, reads as follows:

EXECUTIVE ORDER

The official title of the United States Board on Geographic Names is changed to UNITED STATES GEOGRAPHIC BOARD.

In addition to its present duties, advisory powers are hereby granted to this board concerning the preparation of maps compiled, or to be compiled, in the various bureaus and offices of the government, with a special view to the avoidance of unnecessary duplications of work; and for the unification and improvement of the scales of maps, of the symbols and conventions used upon them and of the methods representing relief. Hereafter, all such projects as are of importance shall be submitted to this board for advice before being undertaken.

THEODORE ROOSEVELT

THE WHITE HOUSE,
August 10, 1906

The representatives of the federal organizations mentioned in the executive order of December 30, 1919, met on January 16, 1920, and perfected the organization by the enactment of by-laws for the government of the Board of Surveys and Maps.

The officers of the board are: Chairman, Mr. C. O. Merrill, chief engineer of the Forest Service; vice-chairman, Dr. William Bowie, chief of the Division of Geodesy of the U. S. Coast and Geodetic Survey; secretary, Mr. C. H. Birdseye, chief geographer of the U. S. Geological Survey.

Standing committees have been appointed to care for the various phases of surveying and mapping. Those committees are:

1. On coordination of work among the federal bureaus.
2. On cooperation between federal and other map-making and map-using organizations and agencies.
3. On technical standards.
4. On topographic maps.
5. On highway maps.
6. On general maps.
7. On hydrographic charts.
8. On control surveys.
9. On photographic surveys.
10. On information.

In addition to these committees there was also organized the Map Information Office, with headquarters at the U. S. Geological Survey, which was directed by the Executive Order.

On all except a few of the standing committees of the Board of Surveys and Maps, representatives of outside organizations will also be appointed.

The public meetings of the board will be held in Washington, D. C., on the second Tuesday of January, March, May, September and November of each year and there will be executive meetings held immediately after those public meetings and also on the second Tuesday of February, April, October and December.

It is interesting to know the steps by which the Board of Surveys and Maps came into existence. The National Research Council had its attention called to the desirability of having an organization that would prevent duplication and provide for cooperation among the federal map-making organizations. The matter was discussed by the National Research Council and was then submitted to the Engineering Council for consideration. On July 1, 1919, the chairman of the Engineering Council, Mr. J. Parke Channing, wrote a letter to the President of the United States in which he called attention to the necessity for the completion of the topographic map of the United States at an early date to meet the needs of the country in its commerce, industries, etc. The Engineering Council recommended the creation of a Board of Surveys and Maps to consider the whole question of coordination of the work of the government in those branches of engineering.

On July 27, 1919, the President of the United States directed the Secretary of War to call a conference of representatives of the surveying and map-making organizations of the government for the purpose of considering the recommendation of the Engineering Council.

This conference held a number of meetings in September, 1919, and on the last of that month sent a report to the President, recommending, among other things, that the Board of Surveys and Maps be created. Added to the report of the conference were a number of exhibits which show the surveying and map-making work carried on by each of the several organizations of the government. The executive order of the President and the organization of the board are considered in the early part of this article.

It is believed that the creation of this Board of Surveys and Maps is a step that will have very far reaching consequences in completing the topographic mapping of the country and in planning standard methods for carrying on work connected with the surveys and map making of various kinds employed in both government and other organizations and agencies.

Maps have been made in this country ever since the colonists first landed but there has never been any coordinating agency by which

standards of accuracy could be established for the guidance of surveyors and map-makers. In fact, such an organization as the American Society of Civil Engineers, which is vitally interested in surveys and maps, has no committee to consider these important matters.

It is hoped that the engineers and scientists of the country will cooperate with the Board of Surveys and Maps by making their wants known. If they will do this the board will be able to make the maps of the government of even more use to the public than they have been in the past.

WILLIAM BOWIE
U. S. COAST AND GEODETIC SURVEY,
WASHINGTON, D. C.

THE CINCHONA TROPICAL BOTANICAL STATION AGAIN AVAILABLE

THE lease of the Cinchona Station by the Smithsonian Institution on behalf of a group of contributing American botanists was interrupted by conditions existing during the war. It has now been resumed and the laboratory will be available for American botanists during the coming year.

This tropical laboratory in a botanical garden containing scores of exotic trees, shrubs and vines and other scores of herbaceous perennials from all quarters of the earth is located within a half-hour's walk of an undisturbed montane rain forest, on the southern slope of the rugged Blue Mountains of Jamaica. In the well-kept garden of ten acres and on other parts of the Cinchona plantation of six thousand acres, the visiting botanist can find well-developed specimens of many economic or ornamental plants such as cinchona, tea, coffee, rubber trees, silk oaks, ironwoods, several species of eucalyptus and many others. The dry ridges and sunny valleys of the south side of the Blue Mountains offer many types of peculiar ferns, of epiphytic bromeliads, grasses, mistletoes and lianes. In the rain forest are to be found scores of species of ferns ranging from the very diminutive epiphytic polypodiums of but an inch or two in height to the scrambling pteridiums or gleichenias or climbing lomarias of many yards in length, and to great tree ferns, forty feet in height. Mosses and liverworts are present here in like profusion and grow on all sorts of substrata from the damp soil of the forest floor, the trunk of a tree fern, or even to the leathery surface of the leaf of a climbing fig or fern. There are also dozens of interesting native trees, shrubs and vines and many herbaceous forms which together make parts of the forest a practically impenetrable jungle.

As the vegetation of the main ridge of the Blue Mountains differs from that of the southern ridges and valleys, so that of the beclouded northern slope, especially the hot, moist lower slopes differs from both. In the deep valley of the Mabess River, five miles north of Cinchona, many peculiar mosses, ferns and seed plants, including a wealth of interesting epiphytic species are to be found. There are whole square miles of these northern slopes of the Blue Mountains within a day's walk of Cinchona that have never been explored by the botanist, nor even by the collector.

Botanists wishing to work on plants of the lowlands or the sea coast can make their headquarters in Kingston. Such workers have always been granted the privilege of using the library, herbarium and laboratory at Hope Gardens. These gardens also contain a fine collection of native and introduced tropical plants offering much material for morphological and histological study. Cacti, agaves and other xerophytic plants of the sea coast and the algæ of the coral reefs along the shore afford still other types of vegetation of great ecological, developmental and cytological interest. Castleton Garden, the third botanical garden of the island, has a very different climate from either Cinchona or Hope, for it is located in a hot, steaming valley, twenty miles north of Kingston, where cycads, screw pines, palms, orchids, figs, ebonies and the gorgeous amherstias and other tropical trees grow luxuriantly.

All in all Jamaica probably offers the botanist as great a variety of tropical conditions within a day's walk of Cinchona and a day's drive from Kingston as can be found anywhere in an area of equal size. One of our botanists

who has collected ferns in many tropical regions of both the old and new world says "none equals Jamaica in either number of species or of individuals." Five hundred pteridophytes are known on the island. Another botanist, a student of the mosses, says "the facilities for the study of these plants at Hope Gardens and at Cinchona are probably unequaled anywhere else in the tropics except at Buitenzorg." It is thus evident that the opportunities for the study of many sorts of botanical problems are abundant at Cinchona, Hope and Castleton. It is also clear that there are many botanical problems of prime importance which can be studied only in such environments. There is then every reason to believe that this American tropical station, which is now available, can be made as notable by the work of our own investigators as the famous Dutch garden at Buitenzorg in Java has become in consequence of the work of the Dutch and other European investigators.

Further details concerning the types of vegetation found and the opportunities for research in Jamaica may be found in Science, 43: 917, 1916, and in *The Popular Science Monthly* for January, 1915.

Any American botanist wishing to work at Cinchona may be granted this privilege by the Cinchona Committee, consisting of N. L. Britton, J. M. Coulter and D. S. Johnson. Inquiries for this privilege and for information regarding the conditions under which it may be granted should be sent to the writer.

Duncan S. Johnson
Johns Hopkins University,
Baltimore

ENTOMOLOGY IN THE UNITED STATES NATIONAL MUSEUM

The day has long passed when American scientific activities can be restricted to a narrow field. Whether we regard the economic needs or the intellectual development, we find ourselves compelled to consider the whole range of science, limited only by our resources and the powers of the human mind. In the field of entomology this involves, among other things, access to adequate collections of insects, including not only those found in North America, but the species of the whole world. The leading European countries have long appreciated such needs, and have built up collections to which Americans have to make pilgrimages when engaged in comprehensive studies of insect groups. There is no reason why we should not possess facilities for work at least equal to those of any other country. We have the greatest material resources of any nation at the present time, and certainly are not lacking in the ability to carry on the work.

The species of insects are far more numerous than those of any other group of animals; in fact the described forms exceed those of all other groups combined. Very many of them are of supreme importance and interest to man, as destroyers of our crops, carriers of the germs of disease, enemies of other injurious insects, or sources of some of our most important economic products. All know the value of the silkworm and the honey bee, but few realize the services of the host of parasitic insects, which keep down the enemies of our crops, and without which agriculture would be impossible. All are aware that numerous insects are injurious to plants, but comparatively few know that many of the most harmful of these have been introduced from abroad. The great danger to our crops, or even to our health, may arise from insects accidentally brought from foreign countries through the operations of commerce. The San José scale, dangerous enemy of many fruits, came from Asia; the cottony cushion scale, which once threatened the extinction of the orange industry in California, came from Australia. The gypsy moth, which has cost this country hundreds of thousands of dollars to fight, is European. The cotton boll weevil, even more to be dreaded, invaded the United States from Mexico and Central America. For urgent practical reasons, therefore, as well as in order to complete and organize our knowledge, we need to know the insects of all countries, and to have them represented in at least one American collection.

This obvious requirement of a great collection representing the insects of all lands, can

not be met without Congressional aid. The National Museum, under present conditions, or better, limitations, can not possibly adopt an adequate policy of entomological development. The two prime obstacles are lack of sufficient curators and lack of space. The present force of curators, even with the aid afforded by the members of the Bureau of Entomology, can not arrange and classify the collections already on hand, incomplete as these are. Some of the men work overtime and on holidays, while help is sometimes obtained from those not officially connected with the museum. But all these activities lamentably fail to meet the whole need. The museum should have enough expert curators to keep classified and in order, the available material in every group of insects, and to furnish identifications and other aid to economic entomologists and other workers in every state. Should a sufficient curatorial force be supplied, however, it would be helpless in the present crowded condition of the department. There is hardly room to move around, and almost no space for new cabinets. The only way out seems to be through the erection of a new building of suitable size; fireproof, but not necessarily of any great architectural pretensions.

Granting the building and the curators, with suitable rules and arrangements to ensure the proper care of all the collections, what more should be demanded? Undoubtedly collectors and students would present or bequeath their materials on a scale previously unheard of, because of the great services they had received from the museum and their confidence in it as a repository of types and other priceless specimens. This, however, would not suffice. Funds should be available for explorations within the United States and abroad, to discover insects hitherto unknown or unrepresented in the museum.

With curators, building and adequate collections, we are still confronted by another urgent need. The results of the work done must be made available to scientific men in every part of the country. This can only be brought about through the creation of adequate publishing facilities, insuring the reasonably prompt appearance of each work completed. At the present time authors hesitate to undertake large monographs not knowing when they will see the light of publicity, nor indeed whether they will ever do so.

Prepared by the committees to investigate conditions and needs of the United States National Museum.

ENTOMOLOGICAL SOCIETY OF AMERICA

T. D. A. COCKERELL,
Professor of Zoology, University of Colorado,

HERBERT OSBORN,
Research Professor, Dept. of Zoology and Entomology, Ohio State University,

WM. BARNES,
Surgeon, Decatur, Illinois,

WM. M. WHEELER,
Dean, Bussey Institution, Harvard University.

J. G. NEEDHAM,
Head, Dept. of Entomology, Cornell University,

AMERICAN ASSOCIATION ECONOMIC ENTOMOLOGISTS

JOHN J. DAVIS,
In Charge, Japanese Beetle Project, N. J. State Dept. of Agri.,

VERNON L. KELLOGG,
Sec'y National Research Council,

E. P. FELT,
State Entomologist, New York,

HERBERT OSBORN,
Research Professor, Dept. of Zoology and Entomology, Ohio State University,

E. D. BALL,
State Entomologist, Iowa,

Approved and adopted at St. Louis, Missouri, by the Entomological Society of America on December 30, 1919, and by the American Association of Economic Entomologists on January 2, 1920.

SCIENTIFIC EVENTS

MANGANESE IN COSTA RICA AND PANAMA

MANGANESE deposits have been known in Panama for many years, and some were ex-

tensively worked as early as 1871. None were recorded in Costa Rica, however, until 1915, when American engineers found deposits in western Costo Rica and, under the stimulus of the prevailing high prices, explored many of them. During 1916, 1917, and 1918 about 18,000 tons of ore was exported from Costa Rica to the United States. In October, 1918, the Geological Survey, taking advantage of the presence in Costa Rica of an American geologist, J. D. Sears, had the deposits examined. Dr. Sears afterward visited several new deposits in Panama.

The deposits in Costa Rica are found at several places on the Nicoyan peninsula, in the Province of Guanacaste, which extends along the Pacific coast. Most of the known deposits, and all those which have been the source of the shipments, lie within about 16 miles of Playa Real on the Pacific coast in the northern part of the peninsula. Other isolated deposits occur in the eastern part of the peninsula, near the Gulf of Nicoya. As the central part of the peninsula is covered with dense forest and is difficult to cross, further exploration may bring other deposits to light.

Although deposits of manganese oxides were examined at thirty-six places near Playa Real, most of the ore shipped has been derived from three deposits that lie in an area scarcely 1,000 feet square at Playa Real. These deposits are owned by the Costa Rica Manganese & Mining Co., and American company. At Playa Real, as at many other places in the region, the manganese oxides form very irregular masses, which appear to extend along the crests of hills. The genesis of the deposits is obscure, but sufficient work has been done to show that only a few persist for as much as 100 feet below the surface. Estimates of the size of the known deposits, which, however, are based upon very inadequate data and are therefore probably low, indicate that they might yield 10,000 to 15,000 tons in addition to the 18,000 tons already shipped. The oxides are intimately mixed with silica, so that careful sorting is necessary to produce material containing more than 45 per cent. of manganese. After the oxides are sorted they are carried by lighters to ships anchored near the shore.

The deposits in Panama lie in an inaccessible region along Boqueron River, about 20 miles northeast of Colon. They are about 12 miles southwest of the deposits at Nombre de Dios, which were extensively explored from 1871 to 1902. These deposits are poorly exposed and only a few of them have been explored, but the indications in two small areas warrant an estimate that the deposits there may yield 25,000 to 30,000 tons of high-grade oxides. As there is considerable float along the near-by streams other deposits may be found. In order to export the material, however, roads or tramways must be constructed at considerable expense.

THE CAMBRIDGE NATURAL SCIENCE CLUB[1]

The Cambridge Natural Science Club, founded in 1872, celebrated its 1,000th meeting by a dinner in the combination room of St. John's College, Cambridge, on Saturday, January 24. The president, Mr. J. M. Wordie, was in the chair. There were eighty-three members and guests, and the occasion was taken to bring out a complete list of the members of the club since its inauguration. This shows that of the 330 members 52 are dead, 10 having been killed or died on active service during the war, and that 55, or 16.7 per cent., had received the blue ribbon of science—the F.R.S. Indeed, in returning thanks for the guests, Sir J. J. Thomson, who, although president of the Royal Society and master of Trinity, had never been a member of the club, thought that the proportion of fellowships of the Royal Society was probably higher among members of the club than among fellows of colleges elected on account of their attainments in natural science. He confessed that he had never taken the Natural Science Tripos, though he had often examined others for it, and pleaded in defence that, like Professor W. H. Bragg, also a guest, he had made some vicarious amends by submitting a son to the ordeal. It may be noted that Professor W. H.

[1] From the *British Medical Journal.*

Bragg and his son divided the Nobel Prize in 1915 for work on X-rays. "The Club" was proposed by Dr. J. G. Adami, the recently appointed vice-chancellor of the University of Liverpool, who insisted on the educational value of the club, which, as a past professor, he seemed to rate higher than that of lectures; that ideas struck out in a discussion were often of great value was accepted as true by Professor Marr, who, as one of the senior honorary members, replied to the toast in an amusing speech. On the cover of the menu there was an attractive reproduction of Kneller's portrait of Sir Isaac Newton, painted in 1689, two years after the publication of the Principia, and apparently the only authentic portrait done in his prime. The original portrait is in the collection of the Earl of Portsmouth, but the reproduction was a photograph of the Trinity College engraving executed about 1866 by Oldham Barlow.

FELLOWSHIP OF THE NEW ZEALAND INSTITUTE

AT the annual meeting in 1919 of the board of governors of the New Zealand Institute it was decided to establish a fellowship of the institute, since—apart from Hutton and Hector Memorial Medals, which couuld only be gained by very few—there were no honors attainable in the Dominion for those engaged in scientific research, the number of whom has greatly increased in recent years, while more branches of science are pursued than formerly. This fellowship, which entitles the recipient to place the letters "F.N.Z. Inst." after his name, is limited to forty fellows, and not more than four from now on are to be elected in any one year until the number is complete, after which only such vacancies as occur may be filled.

In order to make a commencement, and as there were many who well deserved recognition for their long and valuable services to science, it was resolved that in the first place twenty original fellows be appointed, these to consist of the living past presidents, together with Hutton and Hector medallists—ten in all, and of ten more members of the institute who were to be elected by the past presidents and medallists from persons nominated by the various affiliated branches of the institute.

The fellowship is to be given only for research or distinction in science, and it is plain that the distinction even now is far from easy of attainment, and that, as time goes on, its value will greatly increase.

The election and appointment of the original fellows took place at the close of 1919, and has resulted as follows:

B. C. Aston, F.I.C., F.C.S.
*‡Professor W. B. Benham, M.A., D.Sc., F.R.S., F.Z.S.
†Elsdon Best.
*†T. F. Cheeseman, F.L.S., F.Z.S.
*†Professor Chas. Chilton, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., C.M.Z.S.
*†‡L. Cockayne, Ph.D., F.R.S., F.L.S.
†Professor T. H. Easterfield, M.A., Ph.D., F.I.C., F.C.S.
Professor C. C. Farr, D.Sc., F.P.S.L., A.M.I.C.E.
G. Hogben, C.M.G., M.A., F.G.S.
G. V. Hudson, F.E.S.
Professor H. B. Kirk, M.A.
†‡P. Marshall, M.A., D.Sc., F.G.S., F.R.G.S., F.E.S.
*D. Petrie, M.A., Ph.D.
†Sir Ernest Rutherford, F.R.S., etc.
Professor H. W. Segar, M.A.
S. Percy Smith, F.R.G.S.
R. Speight, M.A., M.Sc., F.G.S.
Professor A. P. W. Thomas, M.A., F.L.S.
*Honorable G. M. Thomson, M.L.C., F.L.S.
J. Allan Thomson, M.A., D.Sc., A.O.S.M., F.G.S.

*Past President.
†Hector Medallist.
‡Hutton Medallist.

SCIENTIFIC NOTES AND NEWS

PROFESSOR ALBERT A. MICHELSON, of the University of Chicago, has been elected a foreign associate member of the Paris Academy of Sciences to succeed the late Lord Rayleigh.

THE Bruce Gold Medal of the Astronomical Society of the Pacific has been awarded to Professor Ernest W. Brown, of Yale University, for "distinguished services to astronomy." The award was officially announced at the annual meeting of the society on January 31. It is hoped that Professor Brown may be

able to go to California to receive the medal in person at the meeting of the society which will be held on March 27. This is the fifteenth award of the Bruce Gold Medal. It will be recalled that nominations for the medal are received each year from the directors of six great observatories of the world: the Cordoba Observatory, Argentina; the Royal Observatory, Greenwich, England; the Paris Observatory, France, and the Harvard, the Lick and the Yerkes Observatories in America. It is on the basis of these nominations that the directors of the society make the annual award.

At a meeting of the Academy of Natural Sciences of Philadelphia held on February 17, the Hayden memorial geological medal for distinguished work in geology or paleontology for 1920 was awarded to Professor T. C. Chamberlin, of the University of Chicago, on the recommendation of a committee consisting of R. A. F. Penrose, Jr., *chairman,* John Mason Clarke, Henry F. Osborn, Charles D. Walcott and Edgar T. Wherry.

The William H. Nichols medal for the year 1919 was presented to Dr. Irving Langmuir by Dr. Nichols at a meeting of the New York Section of the American Chemical Society on March 5. Dr. Langmuir made an address on "Octek theory of valence."

R. H. Hooker has been elected president of the Royal Meteorological Society. The vice-presidents are J. Baxendell, F. Druce, Sir Napier Shaw and F. J. W. Whipple.

Arthur W. Gilbert, Ph.D., who was professor of plant breeding at the New York State College of Agriculture from 1911 to 1917, has been appointed state commissioner of agriculture for Massachusetts.

Dr. W. A. Setchell has a sabbatical year of absence from his work as head of the department of botany at the University of California and is visiting botanical institutions in the eastern states.

Dr. J. W. E. Glattfeld, assistant professor of chemistry of the University of Chicago, has been appointed temporary research associate of the department of botanical research, Carnegie Institution of Washington, and is spending January, February and March at Tucson, in cooperative work with Dr. H. A. Spoehr, of the staff of the Desert Laboratory.

According to a press dispatch from Geneva Burt Wolbach, of Harvard Medical School, and Dr. John Todd, of McGill University, have arrived there to confer with the general medical director of the League of Red Cross Societies concerning inquiries the league will carry on in Poland in connection with the study of typhus fever. Other members of the mission are proceeding to Poland. Professor George C. Whipple, of Harvard University, has arrived there to take up his work as chief of the sanitary department of the Red Cross League.

Dr. Alonzo E. Taylor, of the University of Pennsylvania, sailed for Europe, February 14, to make a study of food conditions on the continent.

The *Journal* of the American Medical Association states that Drs. William J. Mayo, Rochester, Minn., and Franklin H. Martin, Chicago, who have been visiting South America in the interests of a Pan-American College of Surgeons, started for home from Santiago, Chile, on February 14. In the course of their tour they have visited Buenos Aires, Montevido and Valparaiso, Chile.

The Government of South Africa has appointed an advisory committee to carry out and supervise a botanical survey of the territories included in the Union, with Dr. J. B. Pole-Evans, chief of the division of botany in the Department of Agriculture, as director.

The committee on Scientific Research of the American Medical Association has made the following grants for scientific work: Professor G. Carl Huber, University of Michigan, $400, for study of nerve repair. Professor H. M. Evans, University of California, $400, for study of the influence of endocrine glands on ovulation. Professor E. R. LeCount, Rush Medical College, $200, for study of extradural hemorrhage and of the h-ion content of the blood in experimental streptococcus infections. Dr. E. E. Ecker, Western Reserve University, $200, for a study of the

specificness of anti-anaphylaxis. Dr. Henrietta Calhoun, Iowa State University, $400, for a study of the effect of protein shock on diptheria intoxication.

THE Cornplanter silver medal, which is awarded biennially by the Cayuga County (N. Y.) Historical Society in recognition of service to the historical study and the present welfare of the Iroquois League or Six Nations Confederacy, has been given this year to Mrs. Frederick Ferris Thompson (Mary Clark Thompson) in acknowledgement of her contributions to the Iroquois collections of the New York State Museum and to the conservation of the historical records of the league. Mrs. Thompson's contrbutions to this object have been made in the name of her father Myron H. Clark, a former governor of New York state.

THE seventh lecture of the Harvey Society series will be given by Dr. Otto Folin, professor of physiological chemistry, Harvard University, on "Blood chemistry" at the New York Academy of Medicine on Saturday evening, March 13.

AT a meeting of the American Philosophical Society held on March 5, the program was: "Across the Andes in search of fossil plants," by Edward W. Berry, assistant professor of paleobotany, Johns Hopkins University, and "Interrelations of the fossil fuels—the Paleozoic coals," by John J. Stevenson, professor emeritus of geology, New York University.

DR. ALFRED J. MOSES, professor of mineralogy in Columbia University, has died at the age of sixty-one years.

DR. FRANCIS C. PHILLIPS, professor of chemistry at the University of Pittsburgh for forty years, died on February 16, at the age of sixty-nine years. Professor Phillips was known for his work in the chemistry of natural gas.

SIR JAMES ALEXANDER GRANT, one of the most distinguished surgeons of Canada, known also for work in paleontology, died on February 6, at his home in Ottawa, aged eighty-nine years.

THE department of geology and geography at the University of Michigan is to have a summer camp in the mountains of Kentucky for field work in geology and geography. This camp will open on August 30, and will continue for four weeks. Professor C. O. Sauer, in charge of geography at the university, will be director of the camp and conduct the work in geography. The work in geology will be directed by Professor E. C. Case. The number of students will be limited to twelve in each course. Students from other universities who have finished an elementary course in geology will be welcome to the camp. Full information can be obtained from Professor Sauer.

DR. JOSEPH GRINNELL, associate professor of zoology and director of the California Museum of Vertebrate Zoology, has presented his entire private collection of scientific study skins of North American birds to the University of California. The specimens number 8,312 and represent collections during the period 1893 to 1907. The total ornithological collections in the California Museum of Vertebrate Zoology now amount to 39,659 specimens. The study skins were secured from Los Angeles county, the Colorado Desert, the Mohave Desert, the San Bernardino Mountains, the Santa Barbara Islands, Mt. Pinos in Ventura, Santa Clara county, Los Coronados Islands, the Stikan District in southeastern Alaska, and the Kotzebue Sound District in arctic Alaska. Twenty-seven types of subspecies newly described, and specimens of at least three species of birds now extinct, are included in the collection. There are also many "record specimens." Large series of such birds as the willow ptarmigan, specially selected to illustrate processes of molt are included. There are also long series of birds gathered from appropriate territory to show facts in geographic variation.

THE American Museum of Natural History has published in its *Bulletin* a full report by Dr. Pilsbry on Land Mollusks of the Belgian Congo, one of a series of reports on the fauna of that region. These reports are

based on the collections made by the American Museum Belgian Congo Expedition in cooperation with the Belgian government.

THE *Journal* of the American Medical Association states that the Société de Neurologie de Paris has recently decided to inaugurate an international exchange of views on neurologic questions by inviting neurologists and psychiatrists from other countries to attend a special meeting to be held annually at Paris in July. It is planned to have two days of work with two sessions each day, and some subject is to be appointed for discussion. The first meeting it is announced will be organized in July, 1921, and the subject appointed for discussion at that time is the clinical forms and the treatment of syphilis of the nervous system. Professor J. A. Sicard has been appointed to open the discussion.

WE learn from the *Journal* of the American Medical Association that a notable gathering of members of the medical profession and other friends of the late Sir William Osler attended services in his honor on January 1, in Old St. Paul's Church, Baltimore. The time was set on receipt by Dr. Henry Barton Jacobs, of a cablegram from Lady Osler, stating that the funeral services in England would be held at that hour. The ceremony at St. Paul's was most impressive. The trustees, faculty and student body of the Johns Hopkins University were represented, as well as the nurses of the training school and officials of Johns Hopkins Hospital. The medical and chirurgical faculty of Maryland and the Baltimore City Medical Society were represented by leading members of the medical profession. A memorial meeting of the staff of Mayo Clinic, Rochester, was held on December 31.

VALUABLE data and records, covering two years' research in the cause and effect of influenza, made by Dr. Thomas M. Rivers, and the laboratories of Dr. Bayne Jones and Dr. Lloyd D. Felton, containing apparatus and data of value, were destroyed in the fire which recently broke out on the top floor of the pathologic building in the Johns Hopkins group.

UNIVERSITY AND EDUCATIONAL NEWS

THE General Education Board, founded by Mr. John D. Rockefeller, announces an appropriation of $1,000,000 as a contribution toward a building fund of $3,000,000 for the construction and endowment of a new library and class room building for Teachers College, Columbia University.

AN emergency grant has been made to the University of Cambridge, by the government, of £30,000, payable in two installments, the first of which has been received. The council of the senate has assigned £5,000 to the university library, £4,100 to increase the stipends of various professorships, £1,400 to increase the stipends of eight readers, and £2,575 for various university lecturers.

MR. S. B. JOEL and his brother, Mr. J. B. Joel, have promised the sum of £20,000 for the endowment of a chair of physics in the Middlesex Hospital Medical School, London.

AFTER thirty years of service in the department of chemistry at the University of Iowa, during the last fifteen of which he has been head of the department, Professor E. W. Rockwood has resigned his administrative duties. He will continue his teaching and research.

ASSISTANT PROFESSOR C. N. MILLS, of South Dakota State College, has been appointed professor of mathematics at Heidelberg University, Tiffin, Ohio.

DR. ROGER C. SMITH, of the Virginia Station, has succeeded Dr. M. C. Tanquary in the Kansas State Agricultural College, entomological department. Dr. Tanquary resigned to accept the post of Texas state entomologist.

HOWARD M. TURNER, a consulting engineer of Boston, who recently has been connected with the Turners Falls Construction Company, has been appointed lecturer on water-power engineering at the Harvard Engineering School.

IT is stated in *Nature* that Dr. Samuel Smiles has been appointed to the Daniell

chair of chemistry at King's College, London, in succession to Professor A. W. Crossley. Last year Dr. Smiles was appointed professor of organic chemistry at Armstrong College, Newcastle, and since 1913 he has been senior honorary secretary to the Chemical Society.

DR. T. F. SIBLY, at present professor of geology at Armstrong College, Newcastle-upon-Tyne, has been appointed principal of the University College of Swansea.

DISCUSSION AND CORRESPONDENCE

MATHEMATICS AT THE UNIVERSITY OF STRASBOURG

TO THE EDITOR OF SCIENCE: I take pleasure in transmitting to you a note recently received from my friend and old schoolmate at the Ecole Normale Supérieure, Maurice Fréchet, concerning the opening under French auspices of the University of Strasbourg. From the extent of the mathematical curriculum thereto appended it is clear that the whole university will be on a very substantial basis.

Many readers of SCIENCE may recall that in 1914 just prior to the outbreak of the war Professor Fréchet was planning to come to America as lecturer at one of our large universities with a strong department of mathematics. Students who now wish to study with Fréchet that branch of mathematics in which he is eminent by researches internationally known will have to cross the Atlantic. I may add that Dr. Fréchet speaks English fluently and will doubtless make every endeavor to render profitable to any young American mathematician a sojourn at Strasbourg.

EDWIN BIDWELL WILSON

THE UNIVERSITY OF STRASBOURG

It will be perhaps of interest for readers of SCIENCE to hear that notwithstanding many difficulties, the University of Strasbourg was reopened informally last January. It is in course of reorganization and will be in full working order for the formal reopening which will take place next November, 1919.

As "the end of the University of Strasbourg" has been announced in some neutral papers, we give below the full program of its mathematical department for the next academic year, such as it has been decided upon, in the original French, names being only given in full for men already in Strasbourg.

Lectures are, of course, delivered in French. The library has been considerably increased as far as concerns books written in English, as well as French books.

For further particulars, apply to Professor Fréchet, 2 Rue du Canal, Robertsan, Strasbourg.

MAURICE FRÉCHET

The courses in mathematics offered during 1919–20 are: (1) Preparatory and general mathematics, by Dr. Pérès and an instructor. (2) Differential and Integral Calculus (unassigned). (3) Theoretical and applied mechanics, by Professor Villat and Mr. Veronnet. (4) Astronomy by Professor Esclangon and Danjon. (5) Higher Analysis (spaces of ∞ dimensions, approximative functions, functional calculus), by Professor Fréchet. (6) Differential geometry (2d semester), by Dr. Pérès. (7) Theory of functions (integral functions, elliptic functions with applications), by Professor Villat and ——— (2d semester). Furthermore as preparation for the Agrégation a series of courses (Math. spéciales, Math. élementaries, Calcal diff. et int., mécanique rationelle) are given. Dr. Pérès, director of the mathematical laboratory, and an assistant will offer work in that line, and Professor Fréchet will conduct a colloquium to encourage original research.

PROFESSOR PAWLOW

TO THE EDITOR OF SCIENCE: Knowing the keen interest of all American men of science and particularly physiologists in news from Professor Pawlow, I hasten to send herewith a paragraph from a letter recently received from a well-known physiologist in the south of Russia. For obvious reasons the place and name had at this time best not be made public.

In August of 1919 Professor J. P. Pawlow was still alive in Petrograd. He begged his friends [in Kieff] to send him some provisions, as he was starving. At the end of his letter he writes: "Instead

of science I am busy peeling potatoes." I know nothing about him at present (January 17, 1920), as the north has been severed from the south by the Bolshevick invasion.

Ever since the false announcement of Professor Pawlow's death a few years ago all his friends have been anxiously awaiting word from him. The above is indeed pitiable but at least indicates that he was living seven months ago.

FRANCIS G. BENEDICT

ANOPHELES QUADRIMACULATUS AND ANOPHELES PUNCTIPENNIS IN SALT WATER

WHILE it is well known that *Anopheles ludlowi* and *Anopheles chaudoyei* may pass their larval stages in brackish water, the report[1] of Smith (1904) regarding the occurrence of *Anopheles quadrimaculatus* in brackish water has been either ignored or discredited. *Anopheles crucians* has been found in salt water at times.

It seems desirable to record certain cases of the distribution of larvæ of malarial mosquitoes in brackish water which have come to my observation. Although not numerous these cases indicate that the American species of Anophelines may occur in brackish water rather frequently.

During the summer of 1918, while in charge of a malarial mosquito survey of the zone around Camp Abraham Eustis, Lee Hall, Va., the writer secured several imagoes of *Anopheles quadrimaculatus* and *Anopheles punctipennis* from larvæ taken in brackish water. Later, (1919) a single imago of *A. quadrimaculatus* developed from a collection taken in a brackish pond near Hampton, Va.

On August 21, 1918, in company with Mr. T. B. Hayne, a sanitary inspector in the U. S. P. H. S., the writer was surveying the draws leading off one of the tributaries to Skiff's Creek, near Camp Eustis, when a large draw was encountered on which great mats of algæ (*Spirogyra* and *Œdogonium*) were floating. Such algal mats ordinarily afford protection to mosquito larvæ and it was therefore not surprising that we secured two pupæ and several larvæ of the second and third moults of *Anopheles*. Since the water was slightly brackish, the expectation was that the imagoes would be those of *Anopheles crucians*. During the night, however, two females of the species *A. quadrimaculatus* emerged. On the next day a second trip was made to the same draw and temperature and specific gravity readings were taken, a number of larvæ of all ages being secured. The temperature of the water supporting the algal mats was 27° C. and the specific gravity was 1.0048. From the second collection three females of the species *A. quadrimaculatus* emerged and with them two females of the species *A. punctipennis*.

The source of the brackish water was from tidal flow and the tributary from which the draw led, had a temperature of 25° C. and a specific gravity of 1.0058. The seepage was not great. In this case there is no question that the eggs of *Anopheles* furnished larvæ which were able to resist a quite considerable salinity. Except for the presence of salts, the environment was one ordinarily exceedingly likely to furnish malarial mosquitoes.

During the summer of 1919, while the writer was making a survey of territory in the vicinity of Newport News, Va., much of which had been under the control of our sanitary engineers, a collection was made from a pond between Hampton and Newport News, which had been recently cut off by a dike from the tidal water of a large creek. The specific gravity of the pond water was 1.005 while that of the tidal creek was 1.015. One imago of *Anopheles quadrimaculatus* developed from this collection.

It is quite evident from the cases here recorded that future control work in connection with Anopheline mosquitoes must include rather careful study of the slightly saline waters. In all probability the adult females of *Anopheles* select their breeding places with more reference to favorable temperature, light and vegetation than with reference to the chemical conditions. Field

[1] Smith, J. B., 1904, Report of the N. J. Ag. Exp. Sta. upon the mosquitoes occurring within the state, their habits, life history, etc.

observations to be recorded elsewhere indicate that this is the case and that many times, eggs were deposited where they were unable to survive.

F. E. CHIDESTER
U. S. PUBLIC HEALTH SERVICE

A PARAFFINE RULER FOR DRAWING CURVES

SINUOUS lines of almost any form can be drawn with the aid of a ruler constructed in the following manner. Points are plotted on a sheet of paper which is then placed on a smooth board and slender nails somewhat larger than pins are driven into the wood at each point. A strip of any flexible material such as whalebone, metal or bristol board is bent around to fit the uprights and held in place by other nails. The edges of the paper are then turned up and melted paraffine poured in to a depth of about a quarter of an inch. When the paraffine is thoroughly hardened the nails are draw out, their spaces filled up by means of a hot metal point and the sheet of solid paraffine broken in two along the strip which is in the form of the line to be drawn.

Such a ruler, of course, must be made for each curve, although for a symmetrical one only one half need be made. This method gives an evenly modulated curvature which can be trimmed if necessary. When several graphs are to be grouped together as many trials as necessary can be made in a short time until a good arrangement of them is drawn.

A practical point of importance is to have the liquid as cool as possible before pouring otherwise it will penetrate the paper and become fastened to the substratum. After a little experience a mold can be made quickly, although it requires some time for the cast to harden. For those who do not have occasion to draw many arcuations a device of this kind produces fairly satisfactory results and takes the place of rather expensive splines.

D. F. JONES
CONNECTICUT AGRICULTURAL EXPERIMENT STATION

THE HANDWRITING ON THE WALLS OF UNIVERSITIES

A CORRESPONDENT sends us the following extract from Dr. Geoffrey Martin's popular exposition of "Modern Chemistry and its Wonders" (1915), suggesting that as it applies very largely to American universities also, it may be advisable to reprint it in SCIENCE.

The color industry started in England some fifty years ago, flourished immensely for twenty years and then passed away to Germany, where now gigantic factories control the world's markets.

This loss of supremacy in a world-industry is a fact to make Englishmen sad and thoughtful, and those who have lived, as I have lived, in Germany, and have seen her numerous universities and great technical schools filled with eager students, know perfectly well the reason of this disaster. It is not so much the fault of our practical men—who in energy and judgment and general sagacity are, despite all critics, splendid, full of bold enterprise —as the *fault of our universities*, who have *failed entirely* to get into touch with practical men. Instead of encouraging research—and it was this that laid the basis of the German chemical industry—our university senates have done their level best by legislation to keep our best students off it, or to make it so unprofitable that they prefer to enter some other form of activity. Let me give an instance of how the greatest difficulties are placed by the universities before students attempting to undertake scientific research.

When a student enters an English, and still more a Scottish, university, he sees before him a long series of oncoming examinations. Almost every year he has to pass an examination of increasing difficulty, and the only subjects that count are the stereotyped ones, on which questions may be asked at some forthcoming examination. In an atmosphere of examinations he lives, breathes, and has his being. Finally, after some four to six years' hard work, he passes the B.Sc. examination, which is an examination of considerable difficulty. Now mark, up to this point he has only been learning what others have done before him. At no time has he reached the confines of knowledge, or advanced it in any way. His parents now step in. The father says, "My son, we have given you a good education; for four to six years we have maintained you at a university, and you have shown your ability by passing innumerable examinations

of a highly complicated nature, and it is now time that you pass into the great world to earn your own living.'' And so the young man passes out of the university without ever being even introduced to methods of research, or ever touching the boundaries of human knowledge. Being a university man, he hardly ever passes into the great world of affairs, but retires into the badly paid and despised teaching profession—and the worst of it is that *it is our very best students who invariably turn to the sheltered ranks of the teachers. It is only students who fail to pass the Chinese-like wall of examinations who join the business world and enter factory or workshop.* Perhaps, however, the young man, in spite of every discouragement meted out to him by the university authorities by means of suppressive legislation, is resolved to remain on in order to do research work. He works hard for two years longer (for research work is difficult and laborious), and at the end of that time has discovered enough to produce a small paper—nothing more can be expected after two years' work. Then as a rule this single little paper is not considered sufficient by the university authorities to merit the highest academic recognition, and so he leaves the university with no reward for his extra work. The highest academic honors involving recognition of research work are thus in this country confined to one class of men—namely, to university teachers, who remain on in the laboratories working out problems in science often for years; and the business world, *where the highest inventive and practical ability is really needed,* never or very seldom receives men trained in methods of research. The heads of factories or workshops, and even the directors of huge industrial undertakings, have never been introduced themselves either to the spirit or practise of research, and so are entirely out of sympathy with it. In Germany, however, a different system prevails, and it *pays* a student to remain on in order to undertake research, as it helps him afterwards in obtaining a good position in the industrial world. Such men gradually rise to the top, become directors of firms, and hence a sympathetic view of scientific work has become a characteristic of the German industrial world. It is all a matter of university legislation, and in Great Britain it is hopeless for the average student to attempt to obtain high academic honors involving research, and so he does not try. If any research work is done in this country research students must be *paid* to do it, the payment taking the form of research scholarships! In Germany a celebrated professor can have as many helping hands as he desires to carry on his investigations, his students forming willing and unpaid assistants, who afterwards pass out into the industrial world, carrying methods of research and influence there also. Here, however, students in any numbers can not be got to undertake or assist research going on in the university, for no good of it will come to them. There is nothing fundamentally different between the natures of German and English students. The difference in the enthusiasm for research, however, is that the legislations of the German and English universities are different, so that in Germany research work helps a student in getting a diploma, and so his living, whereas in this country it is of no practical advantage for a student to undertake research work.

SPECIAL ARTICLES

TWO DESTRUCTIVE RUSTS READY TO INVADE THE UNITED STATES[1]

The application of the adage, "an ounce of prevention is better than a pound of cure," to the spread of crop pests has now became an established procedure for the United States through the activities of the Federal Horticultural Board. One of the difficult factors in securing success is learning about pests before they have been introduced or have attracted much attention. The hollyhock rust did not seem important in the mountainous regions of Chili, but it spread over all the world between 1869 and 1886, reaching the United States last, doubtless due to our "splendid isolation" from South America in transportation facilities. The Colorado potato beetle, as another instance, had to leave its native home and food plants to become a recognized menace to crops. It seems worth while, therefore, to call attention to two rust fungi that seem to possess the possibilities of great harm, but which have not yet invaded the United States proper.

The peanut crop is a large and growing industry of the southern states. There is a rust of peanuts widely distributed in South America, and becoming common in the West India Islands. It is usually designated as

[1] Presented to the American Phytopathological Society at the St. Louis meeting, January 1, 1920.

Uredo Arachidis, although a single collection from Paraguay would indicate that it should be called *Puccinia Arachidis.* It has been known to mycologists since 1884, but only very recently has it attracted attention of the cultivator. Specimens received by the writer from W. Robson, of Montserrat, British West Indies, show every leaf covered with the abundant brownish-yellow powder of the fungus. This was in September, 1916. Mr. Robson reports that some seasons it is a serious menace to the peanut crop in that island. Experiments for its control with Bordeaux mixture did not prove promising.

The life cycle of the rust has not been worked out, but as in the case of the chrysanthemum rust the cultivator will meet only with the uredinial stage, for only one kind of spore is produced on cultivated plants. The rust appears to be working its way northward, having been reported from Porto Rico in 1913, and from Cuba in 1915. It has not yet been reported from any part of the United States proper.

The second rust, to which attention should be called, is one on potatoes and tomatoes (*Puccinia Pittieriana*). Little is yet known about it. It was collected by H. Pittier on the wild potato in 1903 and again in 1904 on the slopes of the volcano Irazú in Costa Rica, at an altitude of about 10,000 feet, and was found again in the same region by E. W. D. Holway in 1916. It is mentioned in Pittier's "Plantas Usuales de Costa Rica" under the name *Uredo Pittieri.* More recently specimens have been examined by the writer sent by A. Pachano from Ambato, Ecuador, where it was found in 1918 in the gardens of the Quinta Normal on both potatoes and tomatoes.

For this rust only one kind of spore, the teliospore, is produced in the life-cycle, and these spores germinate at once upon reaching maturity, requiring no period of rest. The habit of the fungus and its mode of distribution are essentially those of the hollyhock rust. In gross appearance, as well as in other characters, it is very similar to the common rust on cocklebur.

The two rusts, to which attention is particularly called, have not yet demonstrated their full capacity for harm, but from their appearance, and from what we know of the introduction and behavior of similar rusts that are highly destructive, there seems little doubt that if once established in a region where suitable crops are extensively grown, they will prove most unwelcome to the cultivator.

J. C. ARTHUR

PURDUE UNIVERSITY,
LAFAYETTE, IND.

THE FIXATION OF FREE NITROGEN BY GREEN PLANTS

IN spite of a considerable amount of negative evidence, the question of the ability of chlorophyll-containing plants to utilize the uncombined nitrogen of the air is still an open one. A large number of experiments with lower forms, especially the grass-green algæ, tend to disclaim any such ability and it has come to be very generally accepted that members of the Chlorophyceæ are not able to use free nitrogen. However, the number of species which have been investigated is small and the culture methods employed have not always been those which are most favorable for the best growth of these organisms. Accordingly experiments were begun in this laboratory a few years ago for the purpose of extending our knowledge over a larger number of species, under culture conditions which would insure a rapid and vigorous growth. Some of the results of these experiments are presented in this brief preliminary note and a more detailed account will appear elsewhere within a few months.

Seven species of grass-green algæ (Chlorophyceæ) were used in the experiments. With the exception of one (*Protococcus* sp.), all were isolated from soil and all species were used in pure culture, understanding by this term a single species free from all other organisms. The cultures were grown in 500 c.c. Kjeldahl flasks on approximately 150 gr. of accurately weighed mineral nutrient agar. Since previous experiments have shown that these forms will not grow in the complete

absence of combined nitrogen, a definite amount of combined nitrogen was supplied in the medium. The full nutrient solution employed contained 0.5 gr. NH_4NO_3 per liter and in the various series this source of nitrogen was replaced by $(NH_4)_2SO_4$, $Ca(NO_3)_2$, asparagine, glycocoll, and urea, the other constituents of the solution remaining unchanged. In all the culture media nitrogen as such was present in approximately equal quantities and each nitrogen source was set up in duplicate series, with and without 1 per cent. glucose. NH_4NO_3, $Ca(NO_3)_2$, and $(NH_4)_2SO_4$ were also used in the presence of mannite. The culture flasks were arranged in series according to the medium and connected by glass and rubber tubing for aeration with ammonia-free air. Three flasks of each series remained uninoculated as checks and two or three flasks in each series were inoculated with the same organism.

At the end of a growing period of from five to seven months the cultures were analyzed for total nitrogen. The Gunning-Kjeldahl method was used for media free from nitrates and where nitrates were present the Förster modification was employed. The average of the determinations of the three checks of a series was taken as the nitrogen content of that medium per unit weight, and any increase in total nitrogen in the culture flasks of that series was regarded as "free nitrogen fixation." In the urea, glycocoll, asparagine, and $(NH_4)_2SO_4$ series no marked increase or decrease occurred either in the presence or absence of glucose or mannite. Marked increases were found, however, in both NH_4NO_3 and $Ca(NO_3)_2$ media in the presence of glucose, the amount of fixation ranging from 6 to 10 mg. per culture in the 1917–18 experiments and from 4 to 13 mg. in the 1919 experiments. Since the initial nitrogen content of the medium was but 22 or 23 mg. per culture, as shown by the checks, this fixation represents an increase in total nitrogen ranging from 17 to 55 per cent. Where mannite replaced glucose in the nitrate media, there was no indication of fixation; and in the absence of both glucose and mannite, there were only slight increases over the checks. Fixation was not confined to any one species, apparently all seven species showing ability to use free nitrogen. The amount of fixation, however, varied somewhat with the different species and seemed to be related to the intensity of growth.

One species of the 1919 experiment exhibited what is apparently a "denitrification" when grown on nitrate media in the presence of mannite. The total nitrogen content of these flasks was from 2 to 9 mg. below that of the checks. However, the same species in the presence of glucose increased the total nitrogen content of the culture. There was also a slight indication of denitrification with this species on nitrate media in the absence of both glucose and mannite.

F. B. WANN

DEPARTMENT OF BOTANY,
N. Y. STATE COLLEGE OF AGRICULTURE

AMERICAN PHYSIOLOGICAL SOCIETY

REPORT OF THE THIRTY-SECOND ANNUAL MEETING

THE American Physiological Society held its thirty-second annual session during the holidays at Cincinnati, Ohio. The scientific and business sessions were called at the school of medicine of the University of Cincinnati. Six half-day sessions were held on December 29, 30 and 31, 1919, for the reading and discussion of scientific papers. In the two business sessions a number of important measures were considered and voted, the most notable of which was the establishment of a new journal for the publication of periodical reviews of physiological progress in subjects of dominant scientific interest.

The important business acts of the council and of the society at the several sessions during the meeting are here enumerated:

1. The annual assessment was fixed at $1.00 for the year 1920.

2. A grant of $125 was made in aid of the publication of the journal, *Physiological Abstracts*, edited by the English Physiological Society in which the American Physiological Society is a collaborator.

3. Professor Donald R. Hooker, of Johns Hopkins University, was appointed managing editor of

The American Journal of Physiology for the year 1920. The society passed a vote of appreciation to Dr. Hooker in recognition of his successful management of the *Journal* since the administration of the *Journal* has been under the control of the society.

4. Professor William H. Howell, of Johns Hopkins University, was nominated as representative of the society on the Medical Division of the National Research Council for the three-year term beginning July 1, 1920.

5. The society at its thirty-first annual meeting at Baltimore, April, 1919, voted approval of a proposition by the council to establish a new journal under the auspices of the society for the publication of reviews of timely topics in the physiological sciences. At the present meeting the perfected plan was announced. It was voted to launch the new journal under the control of the American Physiological Society. A tentative board of seven editors was chosen to represent the biological field of the different societies constituting the American Federation of Biological Societies. Dr. Donald R. Hooker was appointed managing editor for the year 1920, and the sum of $3,000 was set aside from the surplus funds of the *American Journal of Physiology* to guarantee the initial expenses of the new journal. The board of editors announced by the council include four members from the Physiological Society and one each from the Biochemical, Pharmacological and Pathological Societies. The list follows:

Wm. H. Howell, The Physiological Society, Johns Hopkins University.

J. J. R. Macleod, The Physiological Society, University of Toronto.

Frederic S. Lee, The Physiological Society, Columbia University.

Donald R. Hooker, The Physiological Society, Johns Hopkins University.

L. B. Mendel, The Society of Biological Chemists, Yale University.

Reed Hunt, The Society of Pharmacologists and Experimental Therapeutics, Harvard University.

H. Gideon Wells, The Society for Experimental Pathology, University of Chicago.

6. The following new members were nominated by the council and elected by the society at the two business sessions:

Joseph C. Aub, A.B., M.D., instructor in physiology, Harvard Medical School, Boston, Mass.

Francis M. Baldwin, A.B., A.M., Ph.D., associate professor of zoology, Iowa State College, Ames, Iowa.

Stanley R. Benedict, A.B., Ph.D., professor of chemistry, Cornell Medical College, New York City.

Felix Chillingworth, M.D., assistant professor of physiology and pharmacology, Yale University, New Haven, Conn.

Isabelo Conception, M.D., assistant professor of physiology, University of the Philippines, P. I. Care War Department, Insular Bureau, Washington, D. C., for 1920.

Chas. H. O'Donoghue, B.Sc., D.Sc., professor of zoology, University of Manitoba, Winnipeg, Canada.

Nathan B. Eddy, M.D., lecturer in physiology, McGill University, Montreal, Canada.

Andrew C. Ivy, Ph.D., professor in physiology, Loyola University, Chicago, Ill.

Merkel Henry Jacobs, A.B., Ph.D., assistant professor of zoology, University of Pennsylvania, Philadelphia, Pa.

Theophile K. Kruse, A.B., A.M., Ph.D., assistant professor of pharmacology, University of Pittsburgh, Pa.

Spencer Melvin, M.D., professor of physiology, Queen's University, Kingston, Ontario, Canada.

Walter R. Miles, A.B., A.M., Ph.D., research psychologist, Nutrition Laboratory, Carnegie Institution, Boston, Mass.

Lillian Mary Moore, B.S., M.S., Ph.D., instructor in physiology, University of California, Berkeley, Calif.

Andrew Theodore Rasmussen, A.B., Ph.D., associate professor of neurology, University of Minnesota, Minneapolis, Minn.

John Tait, M.D., D.Sc., professor of physiology, McGill University, Montreal, Canada.

Geo. A. Talbert, B.S., assistant in physiology, University of Chicago, Chicago, Ill.

Homer Wheelon, A.B., M.S., M.D., assistant professor of physiology, St. Louis University School of Medicine, St. Louis, Mo.

7. The officers elected by the society for the year 1920 are:

President, Warren P. Lombard, University of Michigan.

Secretary, Charles W. Greene, University of Missouri.

Treasurer, Joseph Erlanger, Washington University.

Councillor for the 1920–23 term, Carl J. Wiggers, Western Reserve University.

8. Article IX. of the Constitution was amended to enable the society to control and publish jour-

nals other than the *American Journal of Physiology*. The amended article reads:

Article 1, Section 1. The official organs of the society shall be the *American Journal of Physiology* and such other journals as the society shall from time to time establish. These the society shall own and manage.

Section 2. The management of the journals shall be vested in the council. The council shall make a full report to the society at each annual meeting on the financial condition and the publication policy of the journals.

9. The following resolutions were passed:

(1) That this society concurs in the opinion that the present multiplicity and duplication of work in respect to abstracts of the literature in its field is unsatisfactory.

That we are in general sympathy with the effort along the general lines suggested by the Concilium Bibliographicum to simplify and coordinate such work on an international basis in respect to lists of titles and brief abstracts, while retaining to each national society complete freedom in respect to publications in the fields of review and critique.

(2) That the Council of the American Physiological Society extends its very great appreciation of the hospitality of the Daniel Drake Society which contributed so largely to the pleasures and convenience of the members at the council meetings.

(3) That the cordial thanks of this society be extended to the authorities of the University of Toronto and to its local committee for their invitation to meet at Toronto at the present time and for their preparations for such meeting, which unforeseen circumstances prevented; that it is the hope of this society that another and early opportunity may be given to meet at the University of Toronto.

(4) That the American Physiological Society hereby expresses its very great appreciation of the courtesy and hospitality extended to its members and guests by the officers and faculty, and particularly by the local committee, of the college of medicine of the University of Cincinnati which have gone far to make this meeting an unusual success.

SCIENTIFIC PAPERS

The society met in joint session with the American Federation of Biological Societies for two of its six scientific meetings and one very profitable demonstration session was held on the second afternoon. The program which follows contains 58 papers that were read and discussed beside 19 papers announced by title only.

SCIENTIFIC PAPERS

Observations on the physical efficiency tests used by the Royal Air Force of England: EDWARD C. SCHNEIDER, Wesleyan University.

Observations on the distribution of glycogen in some invertebrates and fishes: J. J. R. MACLEOD, L. KILBORN and R. S. LANG, University of Toronto.

Further observations on ether hyperglycemia in the absence of the adrenals: G. N. STEWART and J. M. ROGOFF, Lakeside Hospital, Cleveland.

Further observations on the relation of the central nervous system to epinephrin secretion: G. N. STEWART and J. M. ROGOFF.

The etiology of ricketts: E. V. MCCOLLUM.

The rôle of fat soluble vitamine in human nutrition. Its suggested relationships to rickets: A. F. HESS.

Preliminary observations on the relation of bacteria to experimental scurvy in guinea-pigs: M. H. GIVENS and G. L. HOFFMAN, Western Pennsylvania Hospital, Pittsburgh.

Further studies on the use of water soluble B in the treatment of infant malnutrition: WALTER H. EDDY, New York City.

Is fibrinogen formed in the liver? A. P. MATHEWS, University of Cincinnati.

Anaphylactoid phenomena: PAUL J. HANZLIK and HOWARD T. KARSNER, Western Reserve University.

Further studies in experimental excitation of infections of the throat by chilling the body surface: STUART MUDD, SAMUEL B. GRANT and ALFRED GOLDMAN, Harvard Medical School.

Some observations on dark adaptation of the peripheral retina: M. DRESBACH, JOHN E. SUTTON, JR. and S. R. BURLAGE, Albany Medical College.

Paradoxical pupil dilation following lesions of afferent paths: JOSEPH BRYNE, Fordham University.

The interpretation of certain muscle phenomena in terms of "all or none": T. K. T. KRAUSE, University of Pittsburgh.

Heat production in the Cardia Sphincter of the turtle: C. D. SNYDER, Johns Hopkins Medical School.

Some remarks on catalase: THOS. C. BURNETT, University of California.

Adrenal secretion in pain and asphyxia: W. B. CANNON, Harvard Medical School.

The cardio-respiratory metabolic function: R. G. PEARCE, Akron, Ohio.

Character of the sympathetic innervation of the retractor muscle in the dog: C. W. EDMUNDS, University of Michigan.

A comparison of the physiological effects of Alpha and Beta rays: ALFRED C. REDFIELD, University of Toronto.

On the origin of the muscular tremors, clonic and tonic spasms, in parathyroid tetany: A. B. LUCKHARDT, M. SHERMAN and W. B. SERBIN, University of Chicago.

The rôle of catalase in the organism: W. E. BURGE, University of Illinois.

Significance of concentration as applied to substances in the blood plasma: R. T. WOODYATT.

Alkaloid diffusion in physical and biological systems: G. H. A. CLOWES and A. L. WALTERS.

The adjustment to the barometer of the hemato-respiratory functions in man: YANDELL HENDERSON and H. W. HAGGARD.

A convenient permanent urease preparation: OTTO FOLIN.

Relation of anesthesia to respiration: SHIRO TASHIRO.

New methods for the study of blood pressure in man and in the dog. a. Continuous systolic tracings in man. b. Indirect determination of blood pressure in the unanesthetized dog: ALFRED C. KOLLS, Washington University, St. Louis.

Determination of the circulation time in man and animals: A. S. LOEVENHART, BENJ. H. SCHLOMOVITZ and E. G. SEYBOLD, University of Wisconsin.

The critical level as blood pressure falls: WALTER B. CANNON and MCKEEN CATTELL, Harvard Medical School.

Basal metabolism during traumatic shock: JOSEPH C. AUB and DONALD CUNNINGHAM, Harvard Medical School.

The effects of some anesthetics in shock: MCKEEN CATTELL, Harvard Medical School.

Acidosis as a criterion of shock: B. RAYMOND, University of Chicago.

The blood in clinical shock: G. C. WEIL and C. C. GUTHRIE, University of Pittsburgh.

The rôle of the vagi and the splanchnic nerves in the genesis of shock from abdominal operations: A. C. IVY, Loyola University.

Microdissection studies on the fertilization of the star fish egg: ROBERT CHAMBERS, Cornell University Medical College.

Further studies on the action of Acacia and associated colloids: T. K. T. KRUSE, University of Pittsburgh.

Studies on the responses of the circulation to low oxygen tension. II. The electrocardiogram during extreme oxygen want: CHAS. W. GREENE and NEWTON C. GILBERT, Medical Research Laboratory, Air Service.

The influence of low oxygen tensions on venous blood pressure in man: EDWARD C. SCHNEIDER, Wesleyan University.

Observations on the pathological physiology of chronic pulmonary emphysema: R. W. SCOTT, Western Reserve Medical School.

Electron tube amplification with the string galvanometer: ALEXANDER FORBES and CATHERINE THACHER, Harvard Medical School.

Observations on the capillary blood pressure in man with demonstration of apparatus: D. R. HOOKER and C. S. DANZER, Johns Hopkins Medical School.

Some cardiac and vascular reactions to small hemorrhages: WALTER J. MEEK and J. A. E. EYSTER, University of Wisconsin.

Time relations of the heart cycle as shown by the carotid pulse: W. P. LOMBARD and OTIS M. COPE, University of Michigan.

Further experiments on the effect of warming and cooling the sino-auricular node in the mammalian heart: BENJ. H. SCHLOMOVITZ, University of Wisconsin.

Studies on catalase: R. J. SEYMOUR, Ohio State University, Columbus.

Further results on the physics of sphygmography: A. M. BLEILE and CLYDE BROOKS, Ohio State University.

Effects of breathing dry and moist air: E. P. LYON and ESTHER GREISHEIMER, University of Minnesota.

Vascular reactions to epinephrine in solutions of various concentrations of hydrogen ions: C. D. SNYDER and W. A. CAMPBELL, JR.

The effect of the subcutaneous injection of adrenalin chloride on blood pressure, pulse rate and the basal metabolic rate in man: WALTER M. BOOTHBY and IRENE SANDIFORD, Mayo Clinic.

Removal of the duodenum: F. C. MANN, The Mayo Clinic.

The experimental production of edema as related to protein deficiency: EMMA KOHMAN, University of Chicago.

Susceptible and resistant phases of the dividing sea-urchin egg when subjected to various lipoid-solvents especially the higher alcohols: F. M. BALDWIN, Iowa State College.

Effect of glutamine production on urinary nitrogen: CARL P. SHERWIN, M. WOLF and W. WOLF, Fordham University.

The excretion of a red pigment in the sweat by man: M. H. GIVENS, V. L. ANDREWS and H. B. MCCLUGAGE, Western Pennsylvania Hospital, Pittsburgh, Pa.

Urochrome excretion as influenced by diet: Carl Pelkan, University of California.

The chemistry of gar roe: Chas. W. Greene and Erwin E. Nelson, University of Missouri.

On the protection against eosin hemolysis afforded by certain substances: C. L. A. Schmidt and C. F. Norman.

PAPERS READ BY TITLE

The regeneration of the vagus nerve in the dog: F. T. Rogers, Marquette School of Medicine.

The action of prostatic extracts on the tonicity and contractions of isolated genitourinary organs: D. I. Macht and S. Matsumoto, Johns Hopkins Medical School.

Nervous regulation of respiration: F. H. Scott and C. C. Gault, University of Minnesota.

Recent developments in the field of industrial hygiene: A. H. Ryan, Waterbury, Conn.

The influence of internal secretions on blood pressure and the formation of bile: Ardrey W. Downs, McGill University.

The physiology of reproduction in the opossum: Carl Hartman, University of Texas.

A study of the effect of massage and electrical treatment on denervated mammalian muscle: F. A. Hartman and W. E. Blatz, University of Buffalo.

Function of the Coxal plates of amphipoda: John Tait, University of Toronto.

Keratin: John Tait, University of Toronto.

The effect of pituitary extracts on the absorption of water from the intestine: M. H. Rees, University of South Dakota.

Observations on the thyroid: Walter B. Cannon and Phillip E. Smith, Harvard Medical School.

The effect of pituitary feeding on egg production in chickens: Sutherland Simpson, Cornell University.

The theory of physiological overstrain of the pancreas as the cause of diabetes: A. J. Carlson and V. W. Jensen, University of Chicago.

The nature of the light producing reaction of luminous animals: E. Newton Harvey.

Observations on volume-flow of blood: Robert Gesell, University of California.

Blood flow measurements through the hands: N. B. Taylor, University of Toronto.

On the reality of nerve energy: D. Fraser Harris, University of Toronto.

The respiratory quotient and its uncertainties: J. A. Fries, State College, Pennsylvania.

The subcortical tract for masticatory rhythm: F. R. Miller, Western University.

DEMONSTRATIONS

Apparatus for gas analysis, etc.: J. J. R. Macleod, University of Toronto.

A method for determining the rate of oxygen absorption by blood: W. S. McEllroy and C. C. Guthrie, University of Pittsburgh.

A non-leakable and quantitative volume change recorder: Robert Gesell, University of California.

Foods and food substitutes used in western Russia, and in parts of Poland during the winter 1918–1919: A. J. Carlson, University of Chicago.

A convenient stop cock needle cannula: Paul J. Hanzlik, Western Reserve University.

Demonstration of method for determining tne circulation time: A. S. Loevenhart, Benj. H. Schlomovitz and E. G. Seybold, University of Wisconsin.

Blood pressure apparatus. (*a*) For continuous systolic tracing in man; (*b*) for indirect determinations of pressure in the unanesthetized dog: Alfred C. Kolls, Washington University, St. Louis.

The scientific papers called forth spirited discussion, especially the papers on the secretion of epinephrin by Drs. Stewart and Rogoff, on the one hand, and Dr. Cannon, on the other; and the papers by Dr. McCollum and by Dr. Hess, on the problem of nutritional diseases.

The program, as a whole, was very strong and general satisfaction was expressed at the evidence of promptness with which American physiologists have returned to their scientific investigations.

The executive committee of the federation voted, the Council of the Physiological Society concurring, to hold the next annual meeting at Chicago, in conjunction with the American Association for the Advancement of Science.

Chas. W. Greene,
Secretary

SCIENCE

A Weekly Journal devoted to the Advancement of Science, publishing the official notices and proceedings of the American Association for the Advancement of Science

Published every Friday by

THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK, N. Y.

Entered in the post-office at Lancaster, Pa., as second class matter